Early Cities or Large Villages? Settlement dynamics in the Trypillia group, Ukraine

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Abstract:

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Marco Nebbia

This thesis investigates the development of the largest sites - megasites - in Europe during the Chalcolithic (4th millennium BC) and seeks to discuss their urban nature within the wider settlement context of the Trypillia group in modern Ukraine. The study brings together a number of different archaeological datasets and sources, including remote sensing, field survey and legacy data, into a single GIS-based interpretative framework. The assessment of the potential of these sources of information is carried out in order to establish a new field methodology, as well as a nuanced theoretical framework, for the study of the nature of megasites.

Quantitative analyses are performed in order to ***describe*** trans-scalar patterns in the settlement data, and an interpretative narrative is proposed to ***explain*** these patterns and their relevance for the definition of the 'urban' nature of megasites.

Concepts like 'seasonality' and 'heterarchy' are used to explain the development and the social organization of megasites, which are conceived as temporary gathering places where an 'urban-like' identity starts to develop.

The results suggest that Trypillia megasites can be defined as 'urban forms' within their coeval settlement and social context, but in the long-term perspective of the last six millennia they are "only" large/overgrown villages. The contribution of this thesis is not only to the specific field of Trypillia archaeology, but it also provides new insights into the wider investigation of the origins of global urbanism.

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Acknowledgments

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To my parents

Chapter 1: Introduction

This thesis is part of the 4-year AHRC-funded project, Early urbanism in prehistoric Europe?: the case of Trypillia mega-sites. As part of the Trypillia Megasites Project (henceforth TMP), my thesis contributes to answering some of the project's fundamental research questions. However, it is also a stand-alone piece of research, and while its aims and objectives have emerged from the agenda of the wider project, they are here defined within an independent – but compatible – methodological and theoretical framework.

1.1 The Trypillia Megasites Project (TMP): aims and objectives

The project focuses on the origins of urbanism in Europe by looking at the specific case study of the Trypillia megasites – very large settlement forms (up to 320 ha) that developed in the 4th millennium BC in the modern country of Ukraine. The first archaeological approach to the study of the origins of urbanism was developed by Childe (1928), whose evolutionary and diffusionist perspectives saw European social complexity considered secondary to that of the Near East. The current view is that the earliest towns in Europe date to the Aegean Bronze Age in the late 3rd and 2nd millennia BC (the Minoans and Myceneans). This still widely accepted view has never considered the development of Trypillia megasites in Eastern Europe, the largest of which reached the same extent as the Early Bronze Age city of Uruk. What has drawn attention to the Trypillia megasites, although not until recently, is that they are one of the global exceptions (along with Iron Age oppida and ***Fürstensitze***, see Fernández-Götz and Krausse 2013) to the information and communication limits of agrarian settlements as defined by Fletcher (1995). Fletcher points out the lack of spatial barriers providing local dwelling clusters and script facilitating communication across such large sites. Ukrainian scholars have defined Trypillia megasites as 'proto-urban' settlement forms (Videiko 2004; Kruts 2012), although there is no material evidence of public buildings or a social hierarchy, two of the main characteristics of the Childean checklist of urban attributes (Childe 1950). It is therefore clear that the Trypillia megasites phenomenon needs to be investigated with fresh/primary data and new theoretical and methodological approaches, in order to fully understand this extraordinary phenomenon which occurred in Eastern Europe in the 4th millennium BC.

With this in mind, the primary aim of the Trypillia Megasites Project was to re-evaluate the social and settlement developments in prehistoric Ukraine through a detailed interdisciplinary study of one of these megasites (Nebelivka, Novo'arkhangelsk district, Kirovograd County) in its regional and global settlement context.

A second theoretical aim was to develop an interpretative, ‘bottom-up’ archaeological approach to the ‘Big Question’ of the origin of urbanism - a question which hitherto has been dominated by ‘top-down’ approaches emphasising social evolutionary factors. The project seeks to redress this imbalance by testing competing social trajectories for the Trypillia megasites: hierarchical pathways based upon logistics and provisioning studies; heterarchical models developed using a local ‘bottom-up scale of values’; and the modelling of household nodes and networks in a non-hierarchical manner.

To achieve these aims, the Trypillia Megasites Project objectives are:

1 – the derivation of an accurate settlement plan of Nebelivka, using a combination of modern geophysical investigations of the entire 238-ha site with satellite imagery from the 1960s onwards to reveal changes in site preservation;

2 – the production of an internal chronological sequence for Nebelivka: it is not possible to make progress in understanding a mega-site without an explicit estimate of the number of houses under coeval occupation;

3 – the setting of Nebelivka in a broader micro-regional settlement context through intensive, systematic fieldwalking;

4 – the placing of the Nebelivka macro-region in a regional settlement context through the analysis of satellite imagery of all Trypillia sites over 10 ha in size;

5 – the palaeo-environmental assessment of the human impacts of a megasite by comparison of local alluvial sequences (streambeds) with the overall vegetational history provided by peat-coring in larger basins;
6 – the development of an interpretative understanding of the foundation, growth and decline of Nebelivka;

7 – the comparative study of the emergence of towns elsewhere in the world in order to locate the Trypillia case in a long- term, global picture of the onset and collapse of regional social complexities.

One of the main achievements of the Trypillia Megasites Project has been to produce the first complete plan of a Trypillia megasite using modern fluxgate gradiometry (Chapman et al. 2014b). A complete set of dates have been produced from more than 80 test-pits on a number of different archaeological features, the Bayesian modelling of which is still in progress. Another important achievement of the Trypillia

Megasites Project has been to collect the first pollen sequence associated with a Trypillia megasite, allowing for the study of its impact on the local environment.

This thesis in particular contributed to the investigation of the micro-regional settlement pattern in the surroundings (5 km radius) of Nebelivka, as well as its macro-regional (25 km radius) setting. In addition, this thesis represents a major contribution to the development of an interpretative understanding of Nebelivka's (and by extension the other megasites) foundation, growth and decline.

At the time of writing the underpinning project is still elaborating a final model that includes more results from site investigations. Ultimately, it is intended that the Trypillia Megasites Project – including the contribution of this thesis – will offer a comprehensive interpretative model which explains the place of Trypillia megasites in the global trajectory towards urbanism.

1.2 Thesis aims and objectives

This doctoral study began with an introduction to the Trypillia Megasites Project's research agenda. I will now set out the stand-alone aims and objectives developed in this thesis. Whilst the Trypillia Megasites Project investigations are mostly focussed on a detailed study of different aspects of the internal development of the megasite of Nebelivka and its impact on the local environment, this thesis concentrates on the wider settlement and social context of Nebelivka at different scales.

The dominant manner in which Trypillia megasites have been studied thus far, mostly by Ukrainian archaeologists, has involved investigation at the level of individual settlements. Data has been collected through the use of geophysical and remote sensing-based site plans as well as excavations of single structures and the remains of the house burning process (***ploshchadka***[1]) – often without the use of the stratigraphic method. Thus, megasites have always been conceived of as units of investigations in their own right, rather than being part of a more complex socio-cultural phenomenon. No systematic field survey has ever been conducted in order to place these large settlements into their wider micro- and macro-environmental, or social, contexts. Nor has there been an assessment or analysis of the impressive bulk of legacy data, counting more than 2000 records, of Trypillia sites (Videiko 2004). Thus, starting from this site-oriented history of investigations (see chapter 5 for a broader review of previous studies), this research proposes a nuanced way of

[1] Ukrainian word to describe the deposit of burnt daub characteristics of Trypillia houses, left after the burning of the wattle and daub structure.

approaching the broader contextual settings of megasite appearance, development and demise, by introducing to Ukrainian archaeology a ‘landscape’-oriented approach.

Ukrainian scholar Diachenko developed a number of models that move on from traditional site-oriented narratives, by investigating the settlement context of Trypillia megasites. His research is mostly focussed on population estimates, migrations and marital exchanges (e.g. Diachenko 2012; 2016a). However, Diachenko’s research does not address the impact of megasites in their local environment with primary field data, and is mostly focussed on the Southern Bug-Dnieper interfluve, thus lacking a multi-scalar framework of analysis, characteristic of a landscape approach. Conversely, in my thesis, innovative methodologies and quantitative spatial analyses aimed at investigating large-scale settlement patterns and their diachronic dynamics will be presented, within an appropriate theoretical framework.

The first aim is to investigate the megasites as a social phenomenon and their relationship with other coeval settlements, working towards a better understanding of the nature of these large settlements within the evolution of European and global urbanism. This allows the formulation of an answer to the question of whether Trypillia megasites can be considered early examples of urban forms or not?

The second aim is to develop a theoretical framework and a methodological approach to tackle the study of urbanism and, more generally, of settlement patterns, in the discipline of archaeology.

The research objectives that define the agenda of this research have developed out of objectives 3, 4, and 6 of the Trypillia Megasites Project. They are:

1 – the assessment of the potential of satellite imagery and their analysis for the identification of Trypillia sites and megasites in the micro and macro surroundings of Nebelivka (the project’s case study);

2 – the development of a field survey methodology that enables the discovery of Trypillia sites (as well as other periods) from surface scatters, and a sampling technique that allows for the estimation of the density of subsurface structures;

3 – the definition of a research methodology (combining remote sensing and field survey) that enables the assessment of legacy data and their potential for the

contextualization of the megasite phenomenon within the broader Trypillia settlement patterns;

4 – the quantitative analysis of legacy and primary data in order to investigate the diachronic settlement dynamics of megasites and other Trypillia settlements;

5 – the development of an interpretative model that combines quantitative analysis and social theory in order to explain the formation, growth and demise of megasites and their interplay with the broader Trypillia group.

This thesis distinguishes itself from the Trypillia Megasites Project in two main aspects: the set of data analysed and the scale of investigation. The analysis of the whole published database of known Trypillia sites (Videiko 2004) has never been part of the agenda for Ukrainian scholars. The geographical scale of investigation includes the entire Trypillia area of influence, something else that has never been considered in research agendas as yet.
Both aspects that differentiate this thesis from the overall project will be presented as a stand-alone piece of research that can contribute independently to the aims of the Trypillia Megasites Project, and one which represents a major original contribution to Trypillia studies.

1.3 Setting the scene

The geographical area considered in this research includes the whole territory occupied by the known Trypillia settlements in modern Ukraine (Fig 1.1).

The wider region is framed to the west by the Carpathian Mountains, to the south by the North Pontic steppe, to the east by the Dnieper hydrographic basin, and to the north by the forest zone. It seems that the majority of Trypillia sites are distributed within a forest-steppe biome, giving access to the natural resources found in prairies and forests (today these forests are mainly found in dry gulleys). The two yellow lines in figure 1.1 represent the edges of this biome, characterized by the transition to primarily steppe (to the South) and forest (to the North).

The majority of the study region is part of the Great Eurasian Plain, the largest mountain-free landform in Eurasia, and consists of fertile plains and plateaus. A dense hydrographic network cuts through the landscape in deep river valleys of Pleistocene formation. The network of water bodies was clearly denser at one time, as some of these are now dry gullies of varying depth (Fig. 1.2-1.3).

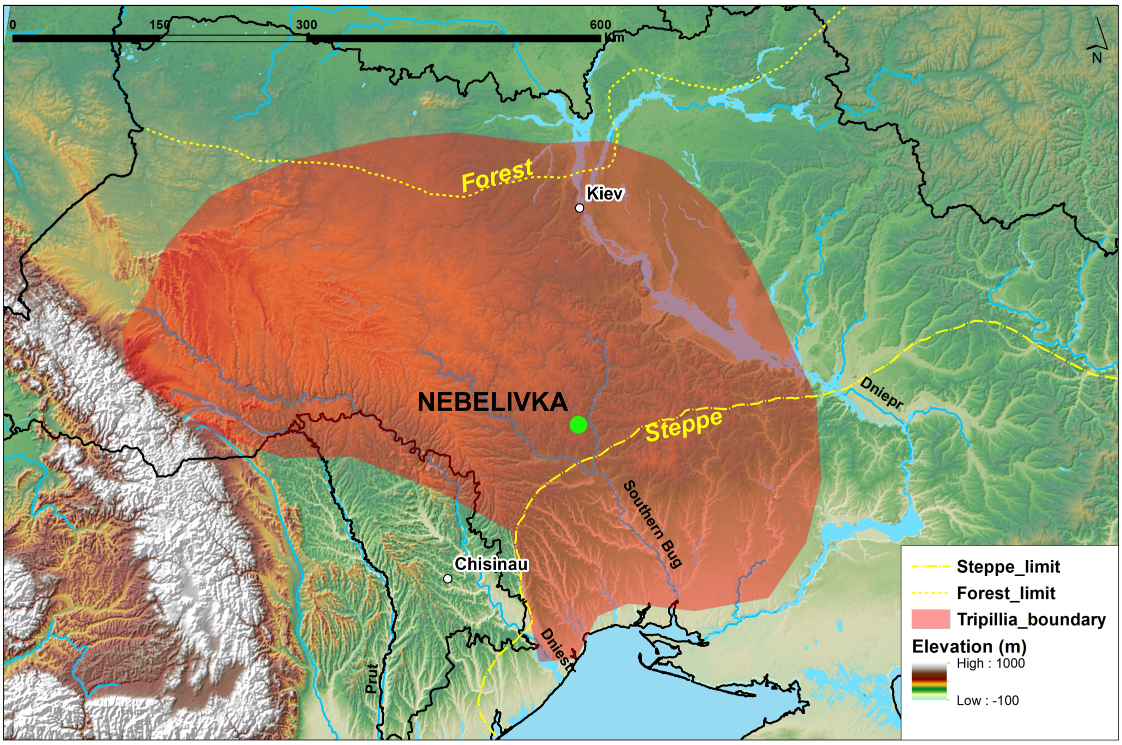

Fig. 1.1. Currently known distribution of Trypillia sites in modern Ukraine. The two dotted yellow lines indicate the two ecotones of steppe/forest-steppe (South) and forest/forest-steppe (North) that frame the Trypillia area of influence. The green dot shows the location of Nebelivka, the megasite investigated by the project.

Fig. 1.2. Dry wooded gulley, southeast of Nebelivka.

Fig. 1.3. Palaeo-channel now a marked depression in the middle of a ploughed field, northwest of Nebelivka.

Unfortunately, no data has been collected in order to date the formation of the hydrographic network and the period of active running water, however, we have evidence for arguing that a palaeo-channel at the megasite of Nebelivka could have been active during the construction of the settlement as the layout of the house rows is interrupted by its presence (Fig. 1.4).

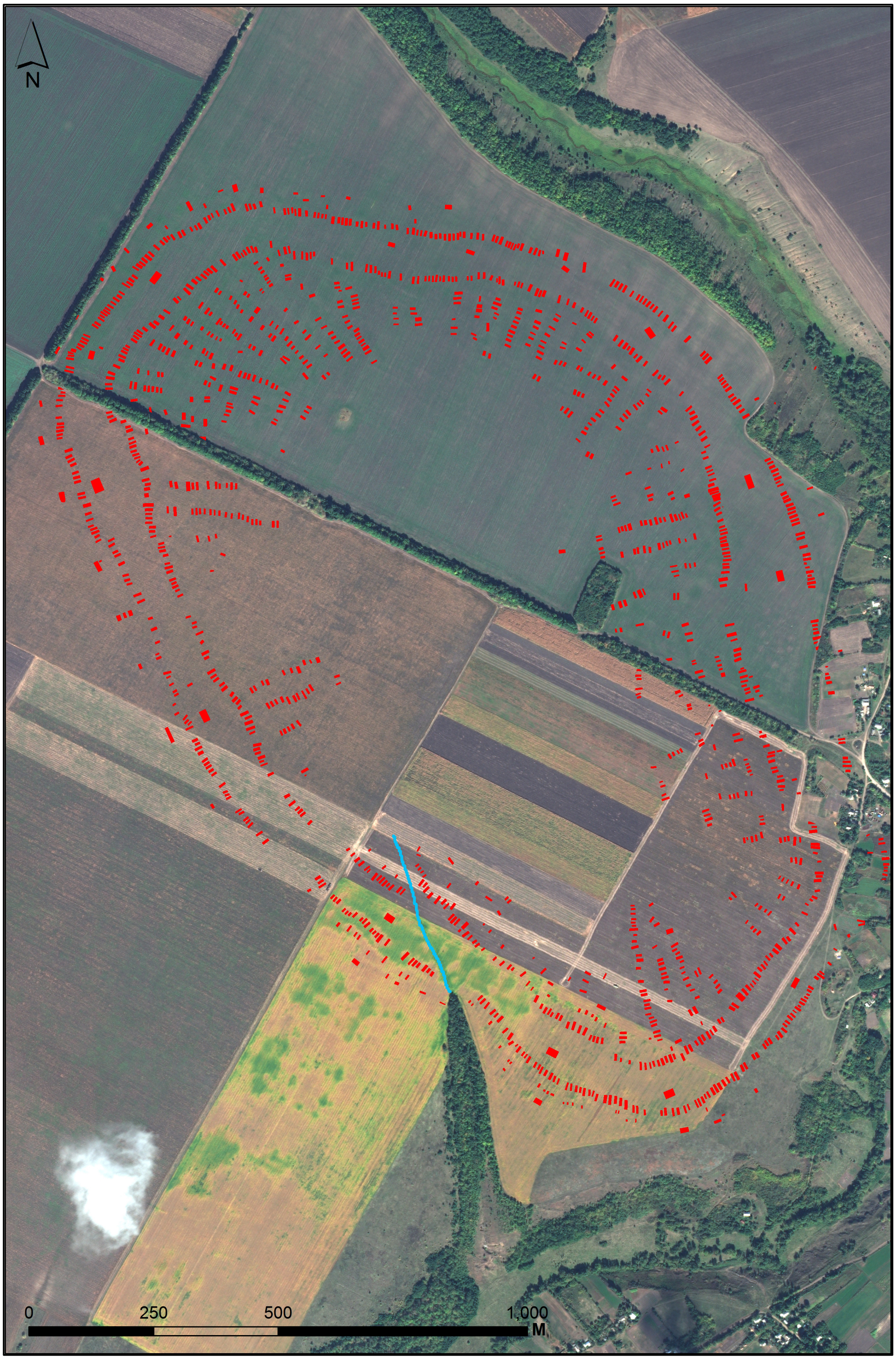

Fig. 1.4. Location of a palaeo-channel at the Nebelivka megasite (marked in blue) and showing how the house circuits are interrupted by its presence.

Three major belts of soil characterize the territory of Ukraine, one of which is associated with the forest-steppe biome: gray forest soil (formed under the broadleaves deciduous forests), the deep chernozem (formed under the prairies), and the podzolized chernozems or degraded chernozems (modified under conditions of encroaching forest) (Fig. 1.5). All of these evolved on calcium-rich loess deposits. Chernozem soils are the most fertile in the world and most of the Trypillia settlements are located on this soil. However, along the Dnieper basin, there is also evidence of settlements sitting on sodden podsolized sandy and clay-sandy soils. Towards the south, Trypillia sites are located in the steppe belt, which is characterized by extensive chernozems rich in carbonates.

Fig. 1.5. Dark topsoil of the chernozem A horizon and the heroic collaborators, west of Nebelivka.

1.4 Thesis outline

This first Chapter has delineated the aims and objectives of the research, the way it intends to contribute to the knowledge and interpretation of Trypillia megasites and has offered a description of the geographical context of the study area. Moreover, it explains how the doctoral research fits into the Trypillia Megasites Project, as well as stands alone as an independent study.

Chapter 2 will begin with a review of the literature of the Neolithic and Copper Age settlement history of the Balkans, this being a natural starting point for introducing the development of the Trypillia group in that the latter shares a number of technologies and material traits with other cultural groups in southeast Europe. In addition, Chapter 2 will detail and summarize the big themes in settlement dynamics that are later to form part of the concluding discussion of the Trypillia megasites' development, growth and demise in Chapter 6.

Chapter 3 will outline the theoretical approach adopted in the research, specifically that which tries to find a middle ground between quantitative analysis and social theory. This chapter's own original contribution can be found in its definition of how large datasets can be statistically analysed, and how large-scale spatial patterns can be interpreted without falling into dry and meaningless numbers.

Chapter 4 will elucidate the results of the assessment of remote sensing for detecting and mapping Trypillia sites (and those of other periods) in the Nebelivka micro and macro regions. Additionally, it will explain how the systematic field survey – the first conducted in Ukraine – contributed to the investigation of the Nebelivka contextual micro-region. Chapter 4 will also describe how the legacy data, derived from the encyclopaedia of known Trypillia sites, has been assessed for reliability and 'cleaned' through a combination of remote sensing and field survey, as well as how the final database has been organized.

Chapter 5 will define the five lines of investigation pursued to answer the research questions set out above by using a number of statistical and spatial analyses applied to the cleaned database.

Chapter 6 will demonstrate how the combination of the quantitative analyses presented in Chapter 5 and social theory can produce an interpretative model that provides an explanation for the nature of Trypillia megasites in their social and geographical contexts, and through the introduction of these nuanced narratives can contribute to the study of European, even global urbanism.

Finally, Chapter 7 will summarize how the research met the aims and objectives of the thesis, highlighting the major original contributions to both Trypillia and 'urban' studies. It will also evaluate the limitations of the research, and propose future avenues for investigation.

1.5 Conclusions

Overall, the thesis aims to establish a new theoretical and methodological framework for the study of Trypillia megasites and, more generally, settlement patterns, with the intention off filling a big gap in the current research agenda. Moreover, the themes addressed and discussed will contribute to the broader debate on the origin and development of urbanism in Europe and worldwide.

Chapter 2: Balkan Neolithic and Chalcolithic settlement patterns: a literature review

2.1 Introduction

The main focus of this Chapter is to review and summarize how settlement patterns developed and changed from the mid-7th millennium to the mid-4th millennium BC, as well as to synthesize previous research conducted across the Balkans. The modern definition of the Balkan peninsula is of an area in south-eastern Europe surrounded by water on three sides: the Adriatic Sea to the west, the Black Sea to the east and the Mediterranean Sea to the south. The northern border is conventionally defined by Romania, but in this Chapter Hungary will be included in the discussion as it saw the development of important archaeological groups during the time period in question (Fig. 2.1).

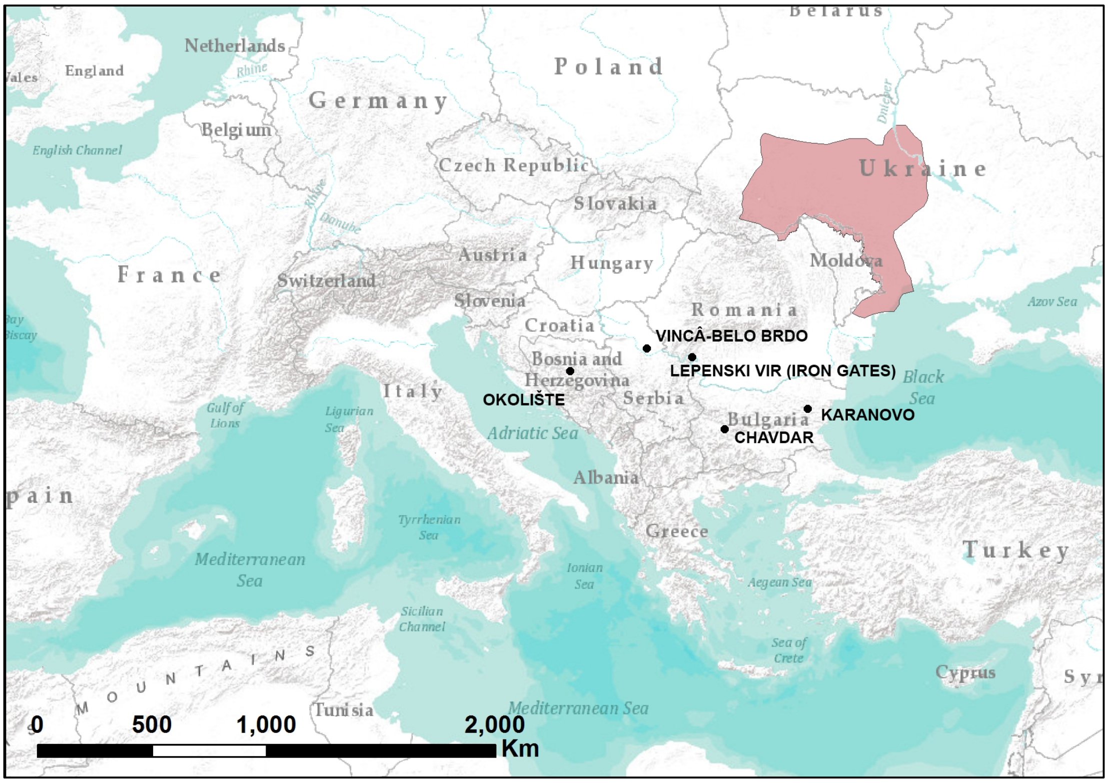

Fig. 2.1. South-East Europe study area in relation to Trypillia group area of influence (in red). Locations of key archaeological sites discussed are provided.

The 'Neolithisation' of Europe has been tackled by many scholars, with different theories formulated to explain the "Neolithic spread" across Europe. Since Gordon Childe (1929; 1936), many syntheses have been produced for Neolithic Europe, such as classic texts by Tringham (1971), Hodder (1990), Whittle (1985; 1996), and Milisauskas (1978; 2002) to cite the main ones. More recently, Bailey (2000) has published a book on Balkan Prehistory focusing specifically on the south-eastern part of Europe.

Different theories have been formulated mainly due to changing connotations of the term "Neolithic". The term initially referenced a specific toolkit of polished stone tools and pottery and later expanded to include farming and sedentary life. Some scholars have proposed a less structured and evolutionary process, but rather fluid and dynamic explanations for this concept (Whittle 1996, 368-371; Chapman 2015). Furthermore, some coeval traits were functionally linked, but it remains for discussion whether these actually amount to a related 'package' or not (Halstead 2011).

We can acknowledge that the Neolithisation process started, chronologically, in the southeastern fringe of the European continent and spread across Central, Western and Eastern Europe (Fig. 2.2).

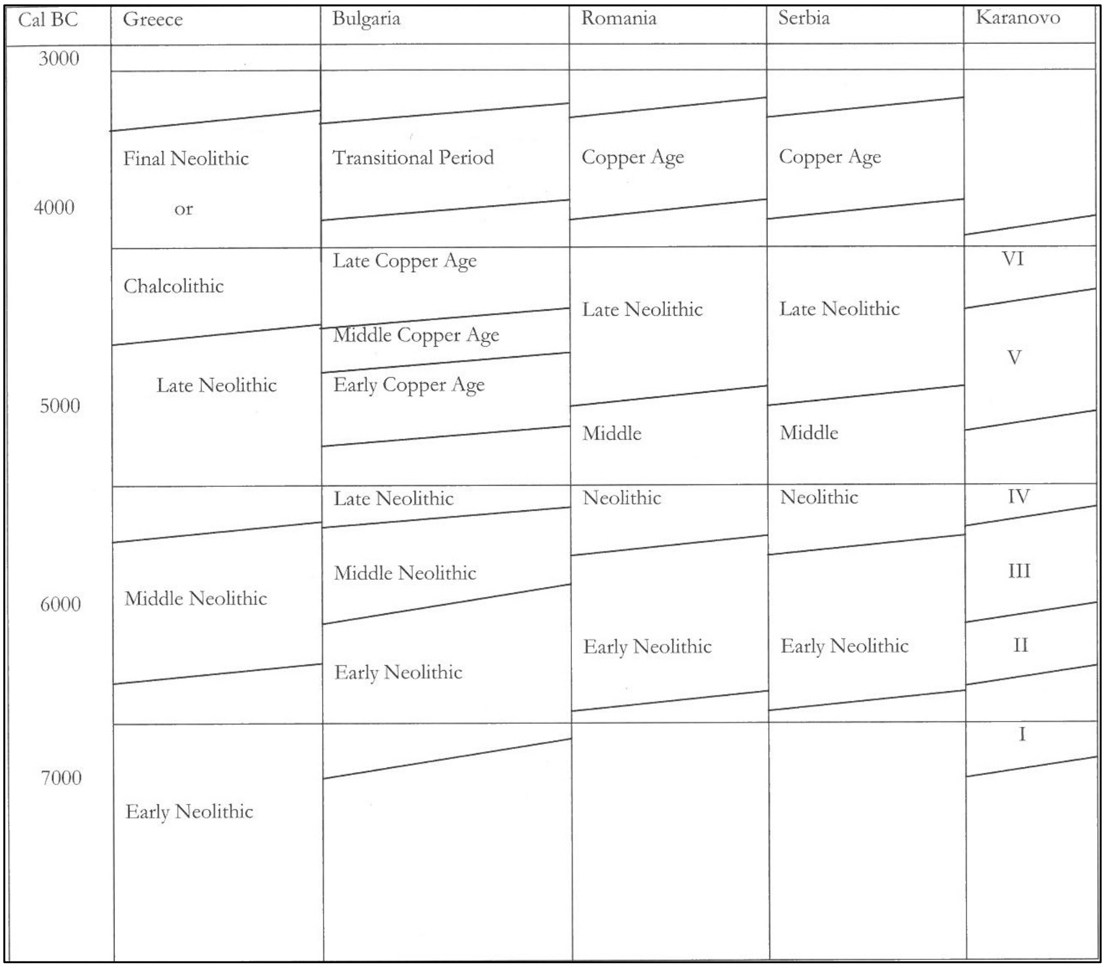

Fig. 2.2. Chronological chart of the main archaeological groups discussed in the Chapter (Chapman and Gaydarska 2006).

There are two main types of Neolithic settlements – tells and flat or unenclosed sites. Many theories have been formulated around the interpretation of tells as a site type and they have changed over time (Fig. 2.3). According to Childe (1957, 60), the topographic expression of tells suggests their permanent occupation with no significant abandonment phases, whereas Whittle (1996b) and then Bailey (1999) argued that, despite their long-term occupation, the life of a tell is characterized by long-running cycles of occupation, abandonment and reoccupation. Chapman discussed how tells in eastern and central Europe possessed a meaning in themselves, rather than representing something else (e.g. cultural diffusion). This notion of meaning depends on the argument that tells represent long-term places ("landmarks"), which have accumulated some place-value over their period of occupation (Chapman 1997). A collection of papers, partly overlapping, on the social and environmental contexts of tell settlements has been recently published (Hofmann et al. 2012).

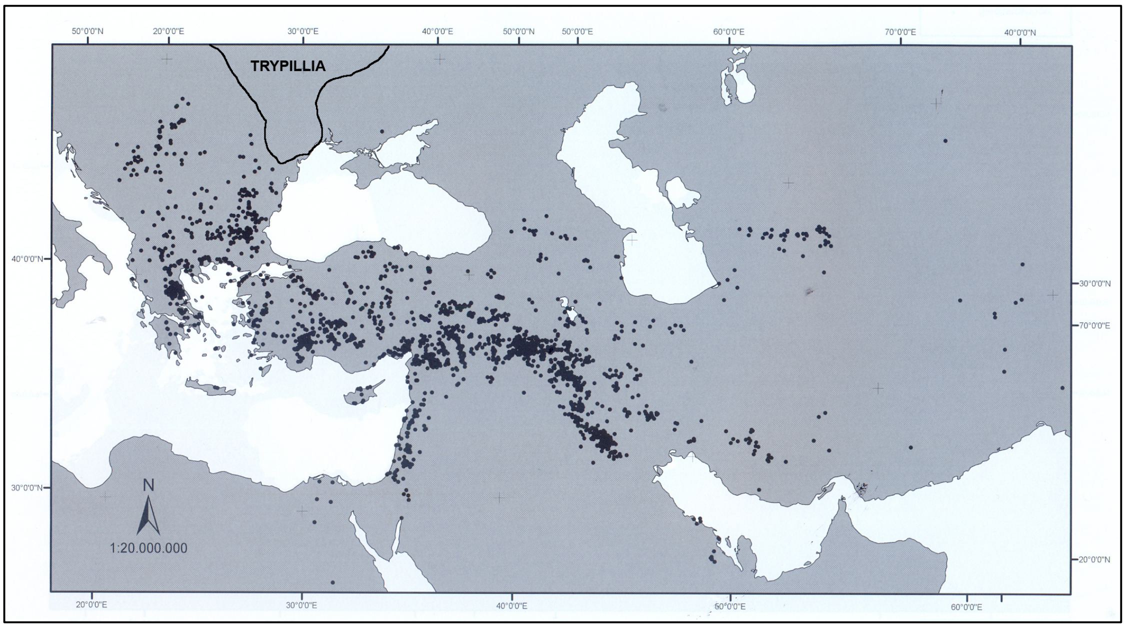

Fig. 2.3. Distribution of tells across Southeast Europe (modified from Rosenstock 2009).

The Podgoritsa Archaeology Project, directed by Douglas Bailey, Ruth Tringham, Ilka Angelova and Ana Raduncheva, has been focussing on the redefinition of the nature of Chalcolithic tells in north-eastern Bulgaria (e.g. Ovcharovo, Golyamo Delchevo, Turgovishte, Radingrad and Podgoritsa), trying to counter traditional interpretations. Bailey argues that the traditional definition of a tell as a permanent settlement stable in function and dimension with a constant population throughout its continuous occupation is somehow wrong, and proposes a redefinition based on the study of 5th millennium BC Bulgarian tells (Childe 1957; Todorova 1978; 1995; Bailey 1999). The new definition considers five different aspects of the traditional idea of the tell. These are: the tell-based activities; the occupation duration; the demography; the off-tell activities; and the tell's spatial demarcation. From the excavation of Ovcharovo, it emerged that animal management and cereal production were the two main activities performed on site, thus making tells the centres for intensified production rather than just for a wide range of domestic activities (Bailey 1999). Moreover, the hydrological instability of the tell's surrounding areas prevented the continuous occupation of the site, as periods of high level of water table made the off-tell lands unsuitable for agriculture. Indeed, soil coring data taken at Podgoritsa showed an absence of agricultural activity during wetter phases (Bailey 1999). This led to a general interpretation of impermanent occupation of the tell, whereas a sequence of several episodes of abandonment and reoccupation, linked to hydrological vacillations of water table level, has been suggested for Ovcharovo and Podgoritsa (Bailey et al. 1998). The temporary nature of tells has been suggested also for another area of South East Europe, namely northern Greece (van Andel et al. 1995). However, Halstead (2005) criticized the hypothesized seasonal nature of settlement at the tell Plateia Magoula Zarkou on the basis of the presence of neonatal lamb remains; something which would attest the occupation of the tell around one month after the suggested lambing season (January-February), which is the main flooding period. More recent studies, based in southern Romania, demonstrate how in the second half of the 5th millennium BC people started to settle on permanent tell settlements, due probably to a more stable hydrological situation (Bailey et al. 2002; Howard et al. 2004[2]). Moreover, the traditional idea of a static tell community is questioned and a general demographic flexibility is proposed related to the labour demand of the sequential stages of agricultural activities which occurred on site (Bailey 1999). In terms of geographic limits, Bailey argues that the old conception of a tell as a static and coherent entity needs to be reviewed in light of the results from the geophysical investigation carried out on the off-tell area at Podgoritsa. The data proved that many of the activities occurred well beyond the topographic limits of the tell, thus showing how the physical space occupied was flexible and variable, depending on the usability of the surrounding land and on the variation on water table levels (Bailey 1999). The redefinition of tells based on the results from the Podgoritsa Archaeology Project stresses the instability and seasonality of this kind of site and underlines the complexity of the social and economic context in which they formed and developed. This interpretation is the fruit of the direct application of the model that emphasizes the mobility and seasonality of the British Neolithic to the Balkan region, without perhaps considering the different social and environmental settings.

The topic of tell formation and distribution has been addressed by many scholars throughout time, and very soon archaeologists underlined how the time-space distributions of tells in Europe did not have the same success everywhere for a number of social and environmental reasons (Rosenstock 2009; 2012). In Greece and Bulgaria tells were rarely the only form of settlement, while in other parts of

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[2] See for climate changes.

Europe tell occupation tended to be the exception to the rule of flat sites, whether nucleated or dispersed (Chapman 1989).

Whatever tells represented in permanence of residence, they resulted from repeated investments over centuries or millennia in substantial dwellings. The nature of this investment - symbolic as well as practical (Sherratt 1990) - is highlighted by comparison with another type of settlement found in large numbers in Greece (Kotsakis 1999).

Although Neolithic tells are usually less than two hectares in extent and form a visible mound, "flat extended" sites can cover 50 hectares or more and are largely preserved in sub-surface pits and ditches with houses. Whilst tells are occupied in successive periods, flat extended sites sometimes date to a single sub-period, with some exceptions, such as Drenovac, which presents a maximum of 6 m of stratigraphy over an overall extent of 35 ha (Perić 2009). Whereas houses on tell sites are rebuilt above their predecessors, habitations on flat sites generally shift laterally over time and for unenclosed settlements it is sometimes difficult to estimate the actual extent of the coeval built-up area. Finally, whereas houses on tells tend to be relatively substantial, free-standing, and sometimes supported with stone foundations, those on flat sites are semi-subterranean round huts or clusters of rectangular rooms with party walls. Circuit walls or ditches often enclosed both types of settlement, although those around flat-extended sites involved much more labour (Halstead 2011).

Regardless of whether they were seasonally occupied or not - that might have changed from different areas and environments across the Balkans - tells provided fixed places (Chapman 1994) in the new cultural landscape created by farming, by patterns of residence that - sedentary or not - were surely constrained by cultivated plots and stored crops to a degree atypical for the previous Mesolithic period in south east Europe. However, flat settlements with massive circuit ditches would have created visible fixed places as well. Tells were the product of repeated investments in individual houses (Halstead 1999) and there is a growing variability in house forms and construction techniques. Investment in domestic architecture tends not only to be greater on tells than flat-extended sites, but also to increase through the Neolithic (Halstead 2011).

From the middle of the 7th millennium BC, people across the Balkans started to live in "new ways"; they began to build permanent and semi-permanent structures. People began to alter their natural environments and in doing so they refashioned the previously unmarked landscape, with the unique exemption of the Iron Gates region that contains one of the largest concentration of Mesolithic burials in Europe (Bonsall 2008, 240). The peculiarity of the dramatic natural geological setting of the Iron Gates region, most likely, made this area a symbolic border ‘marked’ since the Late Mesolithic (Bonsall 2008, 256; Bonsall et al. 1997; 2000; 2008; Borić and Miracle 2004; Radovanović 1996; 2006).

Overall, people started building dwellings out of wood, clay, mud and, sometimes, stone, and enucleating these into small camps and villages. While earlier, more mobile groups had well developed senses of place and identified particular locations within regions, through rivers (see Iron Gates), valleys and forests, uplands and lowlands, the new way of marking places was significantly different. After 6500 BC people marked out specific part of landscapes by constructing in and on them semi-permanent and permanent buildings.

The form of such built spaces varied by region and time, and three main regions of formal variation in architecture can be recognized. To the south, in northern Greece (especially Thessaly) people built rectangular structures with stone foundations and substantial timber frames which they covered with clay and mud daub. In some cases they used sun-dried blocks to build walls by mixing together clay, plants and mud. In other cases, they dug shallow hollows into the ground and erected walls and roofs made of branches and small tree-trunks, then covered them with clay and mud. In a wider area to the north and west (the lower Danube, Serbia, the eastern Hungarian Plain), timber-framed buildings were dominant and very few, if any, buildings with stone foundations or sun-dried blocks have been found (e.g. Struma valley and Macedonia). Instead, other types of structures were common in these northern and western regions: surface level buildings with rectilinear floor plans and wattle and daub, post-framed walls; and, for some scholars (Bailey 2000), roofed, semi-subterranean pit-huts elliptical in plan. However, the residential interpretation of pits has been criticised for many reasons – micro-environmental, the absence of hearths and roofs, and the lack of comfort often associated with Neolithic lifestyles (Chapman 2000, 64-65).

In between these two regions lay a third area, south-central Bulgaria. Here some pit-sites (sites composed of a series of pits) have been dated to the Karanovo I-II, such as Ljubimets. On other sites, such as Karanovo, although timber and post-framed buildings were constructed the builders did not employ stone foundations.

Regardless of these variations in techniques and materials, a common theme unites all the efforts people expended to create their physical environments after the middle of the 7th millennium BC. Each effort succeeded in marking out and enclosing parts of the landscape from previously open terrain (Bailey 2000, 41).

However, this Chapter will not discuss in too much detail different intra-site structures and buildings, instead, the aim is to focus more on overall trends in settlement patterns through time across the Balkans.

2.2 The Iron Gates

The region of the Iron Gates Gorge along the Danube at the border between Serbia and Romania represents the most detailed sequence of settlements of the Mesolithic and Early Neolithic. It has been well investigated over time so that an overall phasing of different settlement patterns has been proposed, stressing the local variability of building typology against other adjacent areas.

Between the 8th and the 6th millennia BC people built durable plaster floors and stone hearths in aggregations along the edges of the Danube on the banks and islands. Considerable attention has been focused on these sites as they are quite different from other settlements established in surrounding regions, due to the absence, for the initial millennium and a half, of pottery and domesticated foodstuffs (Srejović 1972; Radovanović 1996; Bonsall 2008).

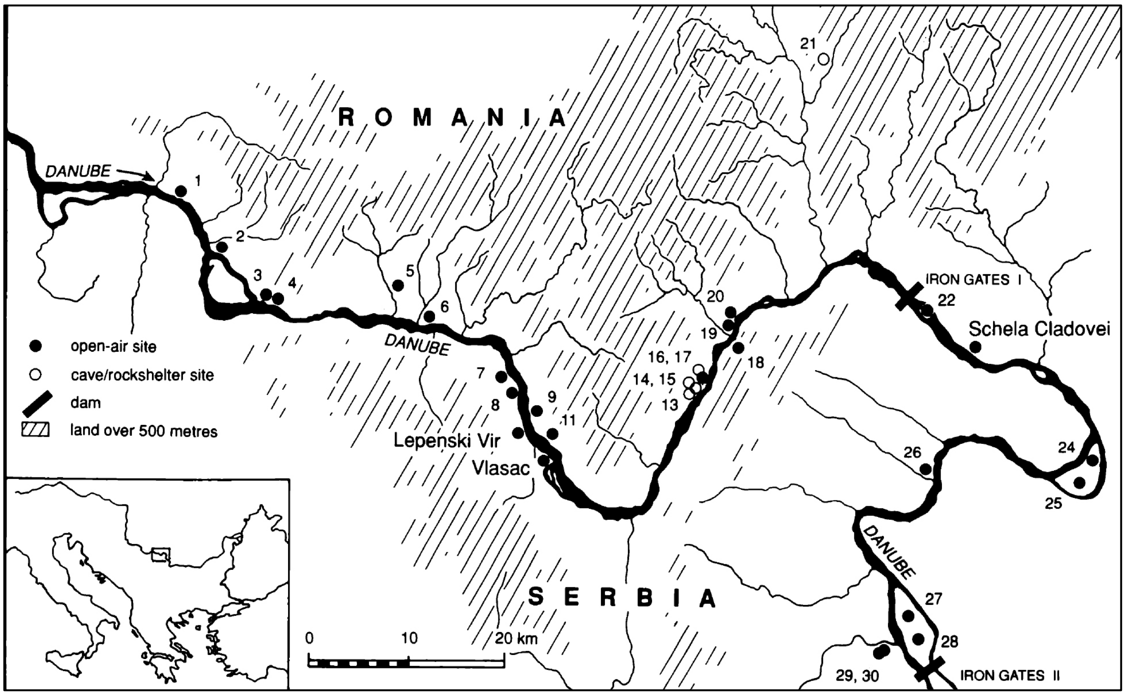

Fig. 2.4. Mesolithic and Early Neolithic sites in the Iron Gates region: 1) Pojejena; 2) Moldova Veche: 3) Livadita Terrace; 4) Alibeg; 5) Gornea; 6) Liubcova: 7) Padina; 8) Stubica; 9) Ilişova; 10) Lepenski Vir; 11) Izlaz; 12) Vlasac; 13) Cuina Turcului; 14) Climente I; 15) Climente II; 16) Veterani Cave; 17) Veterani Terrace; 18) Hajdučka Vodenica; 19) Icoana; 20) Răzvrata; 21) Peştera Hotilor; 22) Ostrovul Banului; 23) Schela Cladovei; 24) Ostrovul Corbului (Botul Piscului); 25) Ostrovul Corbului (Cliuci); 26) Velesnica; 27) Ostrovul Mare; 29) Kula (Mihajlovac); 30) Knjepište (Mihajlovac) (Bonsall et al. 1997).

2.2.1 Late Mesolithic (7200-6300 cal BC)

There are eight open air sites whose radiocarbon dates fall within this time span: Hajdučka Vodenica, Icoana, Padina, Razvrată and Vlasac in the gorge, and Schela Cladovei, Ostrovul Banului, and Ostrovul Mare in the downstream section. Although, only Vlasac and Schela Cladovei have a significant number of radiocarbon dates (Bonsall 2008, 255). For Schela Cladovai, 36 AMS dates placed the occupation of the site between 7100-6300 cal BC (Bonsall et al. 1997). At Vlasac, 18 radiocarbon dates cluster between 6900-6300 cal BC, although not all of them come from secure contexts (Bonsall et al. 1997: Table 2).

A variety of structural remains have been found at Schela Cladovei and Vlasac, with a prevalence of hearths and houses. Hearths were rectangular features defined by large tabular stones. Houses have been interpreted as pit-huts by Bonsall (2008), although Chapman (2002) criticized this view arguing for an overlook of postholes as indicators of the actual residential structures.

Large numbers of burials have been found at both sites, 85 graves at Vlasac and more than 60 at Schela Cladovei. For these, AMS dates confirmed their belonging to the Late Mesolithic (Bonsall et al. 1997; Bonsall 2000; Cook et al. 2002).

2.2.2 Final Mesolithic (6300-6000 cal BC)

This represents a hiatus in the occupation of Schela Cladovei and Vlasac, as very few radiocarbon dates fall within this time phase. The climate records show a decrease in the temperature and increase in precipitation during this period in central Europe, and rivers like the Danube saw an intensification of flooding events (Bonsall et al. 2002). This climate change might have forced people to relocate in the areas above the riverbanks, although the site of Lepenski Vir is the only one occupied during this period in the gorge, probably due to its higher location facing the opposite Treskavac Mountain. Unfortunately, the areas further away from the river have never been surveyed systematically, so the lack of data prevents us from proving this hypothesis. Other site locations have probably been used for fishing activities or landing boats (Bonsall 2008, 265).

2.2.3 Lepenski Vir

The site of Lepenski Vir has a number of features that distinguish it from other Iron Gates sites. Three distinctive features suggest that is was a “sacred site” used for ritual and burial activities; some archaeologists interpreted the ‘famous’ trapezoidal plaster-floored structures as temples or shrines rather than just for residential use (Srejović 1972). Its cultural value probably explains the reason why the site has been in use in a period (6300-6000 cal BC) when others ceased to be occupied on a regular basis (Bonsall 2008).

The earliest occupation – Proto-Lepenski Vir - of the site dates back to the Early-Middle Mesolithic of the region (end of the 10th – end of the 8th millennium BC), and is characterized by the presence of stone structures, occasional burials and one of the earliest examples of rectangular stone-lined hearths (Srejović 1972,62).

From the nearly 100 AMS dates it seems that the site was not occupied during the Late Mesolithic (7300-6200 cal BC), although the Danube Gorges saw a continuity of occupation of other neighbouring sites such as Vlasac and Padina (Borić 2014).

The site is re-occupied after 6200 cal BC, in what is currently referred to as phase I-II, reworked from the initial phasing of Srejović (1972) and Radovanović (1996) (Borić 2002; 2011). This phase is the more prolific in terms of building activity on-site, with the construction of almost 70 semi-subterranean houses with trapezoidal bases furnished with limestone floors and with stone-lined hearths, these being a sign of cultural continuity with the previous Late Mesolithic period (Borić 2002). A remarkable series of objects is the corpus of 90 sculpted sandstone boulders found in association with the trapezoidal floors (Borić 2005). The re-occupation of Lepenski Vir during this moment of instability and abandonment of the Iron Gates area, along with the construction of outstanding features has been interpreted as the sign of a specific interest of the autochthonous foragers who felt the need to 'landmark' (see also the parallel between the shape of the building floors and the opposite mountain) their identity and cultural tradition, at a time when the Northern Balkans started to be occupied by Early Neolithic farmers (Borić 2014; Whittle et al. 2002). The meaning of Lepenski Vir as a place-value in the formation of arenas of social power is examined by Chapman (1993), who discusses the role of the site in the creation of economic and ideological social power among the foragers in the Iron Gates, with special links to the ancestors through houses and burials. Particular emphasis is placed on the recursive seasonal return to the site after flooding events and the solid (flood-resistant) architecture that granted the continuity of use of the trapezoidal structures during this period of environmental instability (Chapman 1993, 100). The solid architecture is remarkably different from the other foraging open-air sites in the gorge This makes Lepenski Vir a seasonal central place for the Iron Gates region. Similar seasonal centrality and its social implications will be discussed – within different contextual settings – for Trypillia megasites in Chapter 6.

Conversely to what Srejović (1972) asserts, the AMS dates show no continuity between phase I-II and III at Lepenski Vir (Borić 2002). While local foragers were adopting Early Neolithic pottery types and polished stone axes (associated with trapezoidal floors), there is no evidence of domesticated animals in phase I-II at Lepenski Vir (Borić and Dimitrijević 2007). At this time, 6000/5950 - 5500 cal BC, there was a significant change in the patterns of occupation at the site. The trapezoidal buildings are abandoned and the floors, sometimes covered with a layer of soil, have been used for burials. Burial customs changed to mostly crouched inhumations (over 20 in primary deposition), which is the typical burial practice for the Balkan Neolithic (Whittle et al. 2002). Furthermore, recent strontium isotopes analyses show that a significant number of the inhumed came from areas outside the Danube Gorges (Borić and Price 2013). Another 'new' feature that is found in phase III are a number of irregular-shaped pits across the site, these being quite typical for the Early-Middle Neolithic of the northern Balkans (Borić 2014, 4499). The site was finally abandoned at around 5500 cal BC.

There are different interpretations of the dynamics of the Mesolithic-Early Neolithic transition in the Danube Gorges, with some scholars arguing for 'contacts' between genetically and culturally unrelated communities with different subsistence economies – mostly based on riverine resources as opposed to farming – (Budja 1999; Chapman 1993; Trigham 2000) with these exchanging prestige goods and commodities (Chapman 1999; Radovanović 2006). Chapman (1999) also interpreted the signs of violence recorded on some skeletons as evidence for violent encounters in the Danube Gorges. Other scholars, instead, see a more continuous 'transition' between Mesolithic foragers and Neolithic farmers, as the two 'identities' cannot be clearly distinguished in the archaeological record (Borić 2005; Bonsall 2008). Moreover, the case of burial 7 in Lepenski Vir has been interpreted by Borić (2003; 2005) as an example of how disarticulated human bones have been used to incorporate Mesolithic remains in an Early Neolithic context.

2.3 Northern Greece

Starting from the south, one of the best-investigated areas in northern Greece is Thessaly and particularly the Karditsa plain (Fig.2.5).

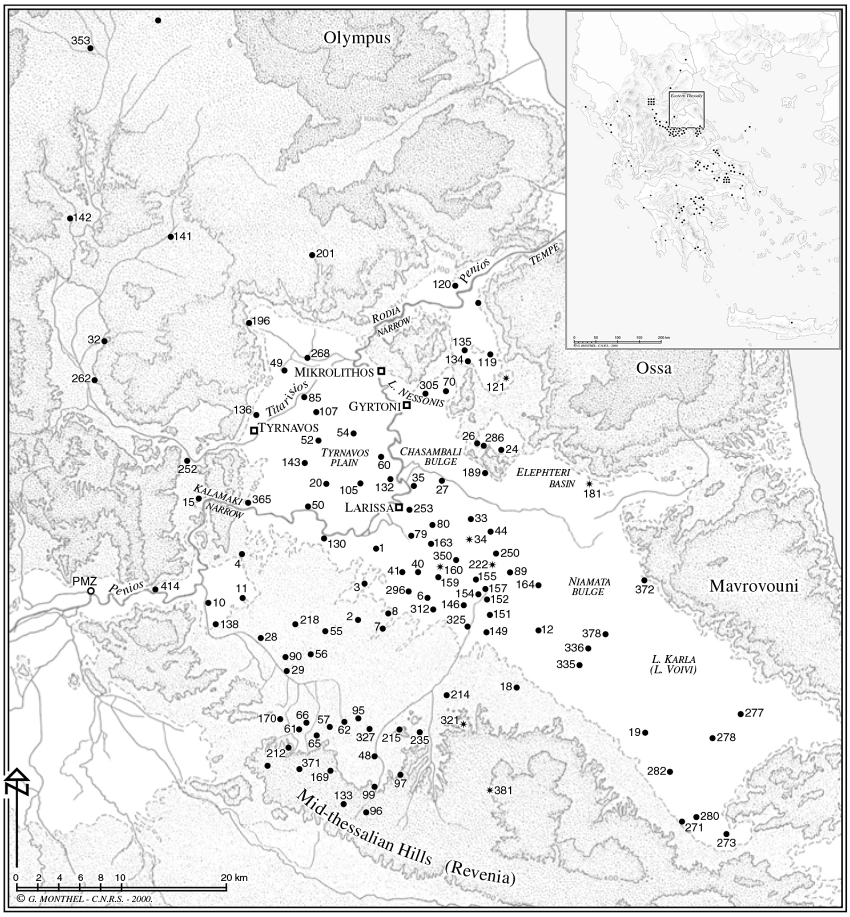

Fig. 2.5. Distribution of Early Neolithic 2 sites (dots) and unspecified Early Neolithic sites (stars) in eastern Thessaly (Karditsa plain). For numbers and names see ATAE (Gallis 1992). Map after Perlès and Monthel (2001).

The exceptional density of long-term Neolithic settlements in Thessaly was recognized from the beginning of the previous century. In the decades that followed, successive surveys gradually increased the number of sites identified, bringing the total to more than 300. In 1984, Halstead exploited an already impressive corpus and offered the first thorough analysis of settlement patterns in Thessaly (Halstead 1984). In the meantime, however, Gallis had resumed surveys in eastern Thessaly with his collaborators, leading to the publication of a systematic "Atlas of prehistoric settlements in eastern Thessaly" (the ATAE). This included several newly discovered sites and refined chronological attributions, as well as various statistics on the chronological distribution of sites, the duration of their occupation, their size, ***et cetera*** (Gallis 1992). Relying on Gallis' Atlas and further geomorphological fieldwork (van Andel et al. 1995), van Andel and Runnels published another study that concentrated on the palaeo-floodplains of the Larissa basin (van Andel and Runnel 1995).

Halstead, as well as van Andel and Runnels, concluded that the distribution of sites was uneven, that sites were clustered rather than dispersed, and that the clustering of sites in specific environments revealed deliberate choices of soil type or topographical preferences (Halstead 1984; van Andel and Runnel 1995). Conversely, Perlès (2001) used a bigger sample of data to claim the opposite, arguing against any site clustering and environmental-driven settlement locations. Instead, she asserts that the settlement patterns presented a remarkable regional variability within Greece and that the main drivers of the non-linear spread of the Neolithic were more of socio-political nature, rather than environmental.

Overall, sites are widespread all over eastern Thessaly, with no particular clustering near the valleys and flood plains or in areas of diversified micro-environments. The absence of clustering, in particular along water sources, is especially striking as this region is characterized by hot and dry summers. Settlement strategies are environmentally driven in the sense that some areas are avoided, either because they were seasonally flooded or marshy, or because they may have been too dry. Detailed regional analysis shows that the highest density of sites is reached in areas that were never flooded – the Revenia and Larissa Plain, although some sites of one group were found on the Revenia Pliocene marls, the others on the colluvial sediments of the Larissa Plain. Thus, no positive relation can be established between settlement choice or settlement density and natural features such as water proximity, floods, soils, and varied topography. On the contrary, the most striking result of these analyses is the regularity of the distribution pattern in the settled areas, even allowing for minor regional variations. The distribution of settlements appears to be independent of variations in topography, soils, proximity of water sources, ***et cetera***. Fundamentally, Early Neolithic 2 settlements avoided some areas, for reasons still unexplained, but spread according to a regular grid of c. 2.3 km in all directions around and between these areas. No "core area" can be identified, and the earliest farming communities appear to have settled in dispersed and varied environments. The dynamic of expansion seems to have followed very different rates according to the region, and even where agriculture was practiced very early, such as in the Argolid, the density of sites remained markedly lower than in Thessaly. Whether on a regional or global scale, the spread of the Neolithic in Greece appears to be a complex, non-linear phenomenon, regulated by sociological factors as much as environmental ones (Perlès 2001).

More recently the use of new technologies such as Remote Sensing is helping in expanding the investigation towards broader areas and in planning and targeting more carefully the survey on the ground. Nevertheless, as a recent remote sensing survey in Thessaly (Larisa and Karditsa Plains) demonstrates, the use of satellite images or other remote sensing datasets cannot solve the problem of flat-sites' "invisibility" (Alexakis et al. 2009). The analysis aimed to combine different datasets in order to automatically detect and map Neolithic settlements, relying on the specific topography and spectral signature of tell sites so that flat-sites were completely excluded from the objective of the research, thus demonstrating that remote analysis is not enough to cover the full spectrum of Neolithic site types.

2.4 Bulgaria

Many excavations have been carried out at Neolithic sites in Bulgaria since 1898 – the date of Father Jerome's expedition (Todorova 1996, 79). However, most of the research, until recent years, has been focused at the intra-site level of analysis, so that long-term interpretation was based on deep time resolution of just a few spots.

The first stage of Bulgarian archaeology, from 1898 to 1947, saw an initial phase of data collection during which information regarding sites and material culture were collected, and museum collections compiled. A few excavations yielded piecemeal information with a lack of stratigraphic accuracy (e.g. at the Veselinovo tell), which misled an entire generation of European prehistorians (Mikov 1933).

The second stage, from 1948 to 1961, started with the publication of Gaul's book (1948), this representing the first scientific attempt to summarize the chronology and geography of prehistoric Bulgaria. During this period, a number of excavations started on a few tell sites (e.g. Ruse, Krivodol, Karanovo) and, following a more stratigraphic approach, they yielded the first relative chronology for Neolithic, Eneolithic and Early Bronze Age Thrace (Georgiev 1961).

The limitations of small sondages that did not reveal the whole surface of the settlements, along with the reduced prehistoric knowledge outside Thrace, were tackled by the next generation of scholars that operated in the third stage of Bulgarian archaeology (from 1961 to present). The application of novel excavation methods and theoretical approaches in Bulgarian archaeology, have provided nuanced chronological sequences and narratives, even outside Thrace. We will now discuss this briefly from a settlement point of view.

2.4.1 Chavdar

The site of Chavdar, located in west Bulgaria, has been occupied since the beginning of the 6th millennium BC, and there are many reasons why people decided to settle in this location (Fig.2.1). Most obviously, the river provided easy access to water. In fact, the course of the river during the 6th millennium BC was much closer to the site than today. Furthermore, a low ridge of hills sheltered the settlement from northerly winds and, opposite the site, a small valley provided easy access to uplands for summer grazing activity (Dennell 1978, 76-80). Overall the region of Chavdar has low agricultural potential, however the village was built in one of the few parts of the valley where the widest range of natural resources was available. These consisted of heavier riverine soil for grazing, forested slope for hunting and lighter loamy soils for planting (Dennell 1978, 100). As in the case of Chavdar, people in other parts of central and south Bulgaria chose similar conditions to settle. While for Chavdar we don't have much information about the internal structure of the village, other sites has been widely excavated and more detail about domestic architecture is known.

2.4.2 Karanovo and Ovcharovo-gorata

Amongst the best studied is Karanovo in south-central Bulgaria (Fig.2.1). At the beginning of the 6th millennium BC people built rows of rectangular surface-level, post-framed, one-roomed structures, and in each horizon of occupation more phases of reconstruction have been recorded (Nikolov 1989). Karanovo is the only satisfactorily published village from the area (Nikolov and Hiller 1997). Another significant site excavated in the 70's is the Eneolithic tell of Ovcharovo in northern Bulgaria, one of the few published sites for this period in Bulgaria (Todorova 1976). An early Neolithic open flat-site, Ovcharovo-gorata, which is located on the nearby river plateau in the Kamčija valley, has been recently investigated by the Museum of History in the city of Tărgoviste and the Bulgarian Institute of Archaeology. This work has shed more light on the earliest phases of the site. The lowest settlement horizon is well documented, displaying a very complex structure consisting of numerous pits which has been interpreted as associated with the remains of houses (Krauss 2006).

2.4.3 The Eneolithic in Bulgaria

The Eneolithic period in Bulgaria has been studied with excavations of major tell sites, with the Podgoritsa project re-evaluating the traditional definition of a tell and integrating off-tell investigations along with the excavation of the main site itself (Bailey 1999). Moreover, Todorova analysed the internal architecture of tell sites in the 5th millennium BC, and worked out some general characteristics shared by the main investigated sites. The Eneolithic settlement was built according to a set plan, where straight passages defined a symmetrical organization of buildings oriented according to the cardinal points, the buildings were set close to each other and the average width of passages was between 0.5 m to 1.20 m. There was a general intention of site fortification through the use of the topography of the village, a general absence of stone work, and the presence in every settlement of a massive central building, more often than not two-storied (Todorova 1978, 48).
More recently, archaeologists began more systematic investigations of the areas surrounding tells and started finding different typologies of sites, flat-sites, workshops, and burials. The field survey carried out jointly by Bulgarian and German institutions between 1997-2001 along the Jantra river valley led to a more complete

hierarchy of Eneolithic sites, where tells are at the top of a much more complicated settlement pattern made up of smaller sites (Fig.2.6).

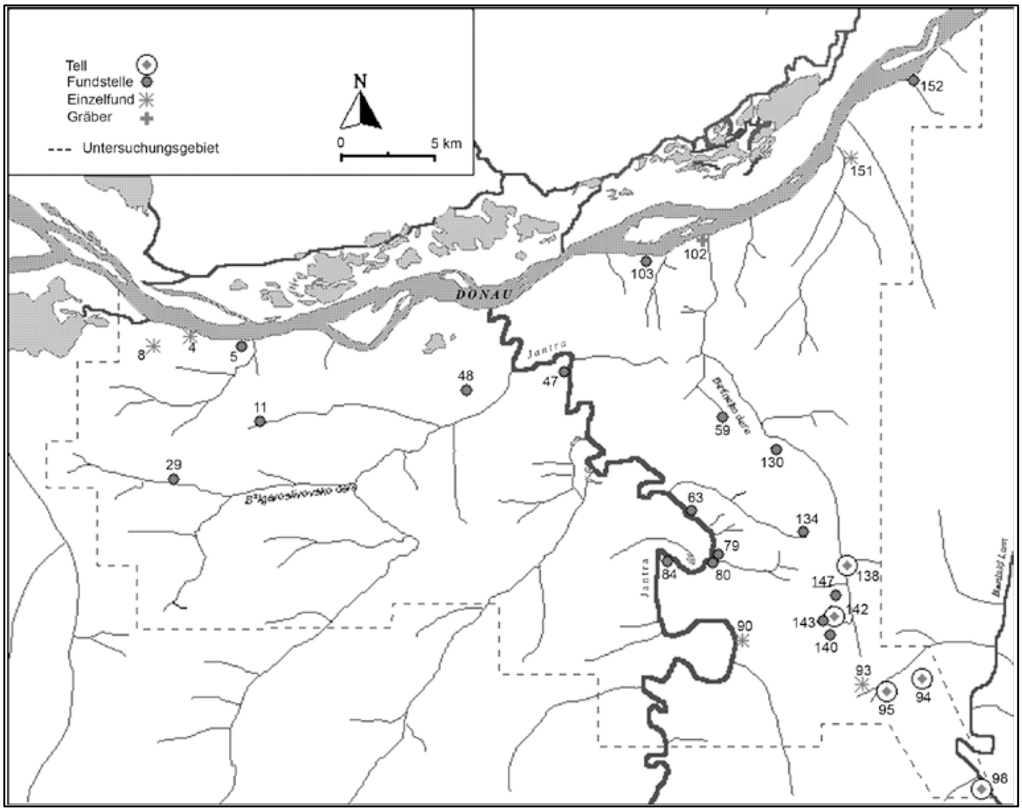

Fig. 2.6. Eneolithic sites on the lower course of the Jantra River (Krauss 2009).

These were recovered during excavations or field survey, and consist of ephemeral scatters of pottery that have been interpreted as workshops related to the main settlements (Krauss 2009). More recently Gaydarska studied settlement patterns during the late Prehistoric period of three micro regions (Sokolitsa, Ovcharitsa and Drama) in southeast Bulgaria from a long-term perspective. A more complete picture of the social and economic aspects of the human/landscape interaction, as well as patterns of changes and continuity from the Neolithic to the end of the Late Bronze Age, has been tackled in depth. In addition, the use of GIS analysis has been introduced for the first time in the study of prehistoric Bulgaria (Gaydarska 2004). The international Kazanlak Valley project carried out in 2009-2011 is the most recent survey project conducted in Bulgaria using modern field survey methodologies, including GIS, satellite images and GPS, in order to detect and map sites from all time periods in the upper Tundzha River (Fig.2.7). The project yielded a number of previously non-recorded sites from the Neolithic to the Middle Ages (Nekhrizov et al. 2012).

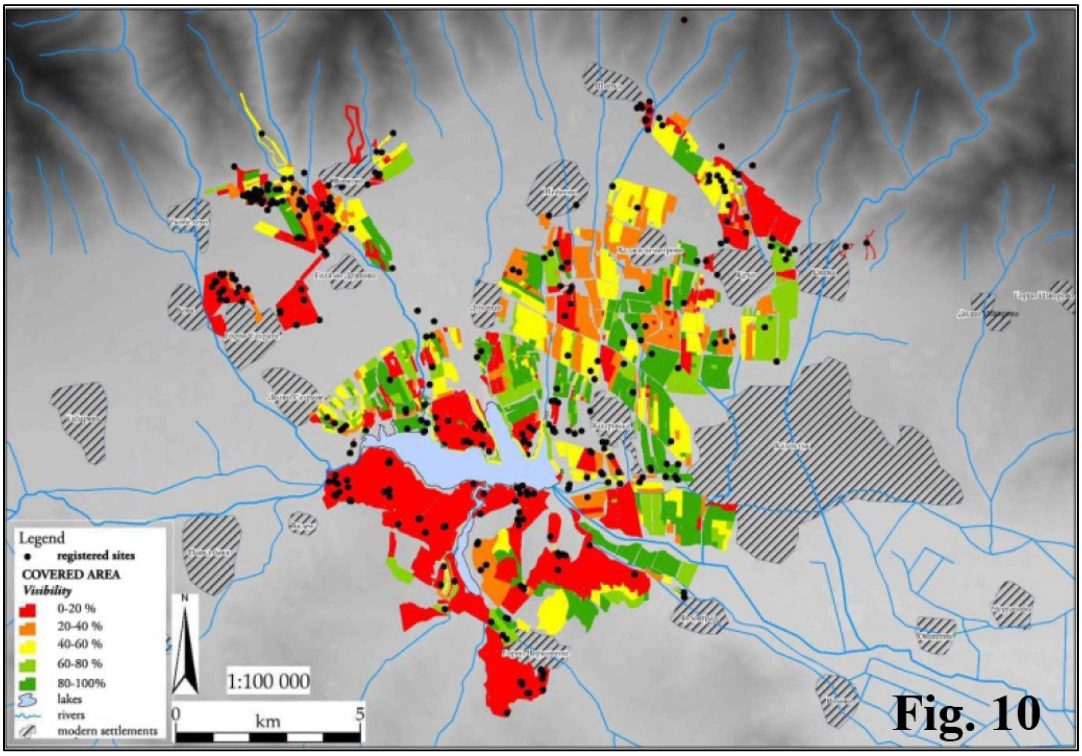

Fig. 2.7. Results of the Kazanlak Valley survey. (Nekhrizov et al. 2012).

2.5 Serbia and Bosnia

In the western Balkans (modern Serbia and Bosnia) it is quite clear that tell sites (such as the Vinča – Belo Brdo mound), small (e.g. Opovo= 3 ha) and large flat sites (e.g. Selevac= 65 ha), co-existed in the same landscape (Fig.2.8).

Fig. 2.8. Distribution of principal Vinča culture sites (shaded area) and some key sites from the adjacent regions (Borić 2015).

2.5.1 The Vinča cultural group

The Vinča culture developed mainly between the modern territories of Serbia, Croatia and Bosnia, Macedonia, south Hungary, Transylvania, and Oltenia, and almost 650 sites have been recorded. Most of the sites are flat, but a number of tells are also known, namely Gomolava, Novi Knježevac, Gračanica, Parţa, Tartăriă and Matejski Brod, and the largest tell at Vinča-Belo Brdo (Chapman 1981, 45; Borojević 2006, 3; Tasić et al. 2015).

The Late Neolithic site of Opovo - located in the Banat - is one of the best investigated Vinča flat sites (Fig.2.9). The Opovo Archaeological Project constitutes the main excavation conducted by Ruth Tringham and the late Bogdan Brukner in the mid 1980's (Tringham et al. 1992).

The Banat is a part of the Pannonian Plain, the great lowland of the middle Danube basin. As a region, the Banat is bounded by the Tisza River to the west, the Danube to the south, and the foothills of the Carpathians in Romania to the east.

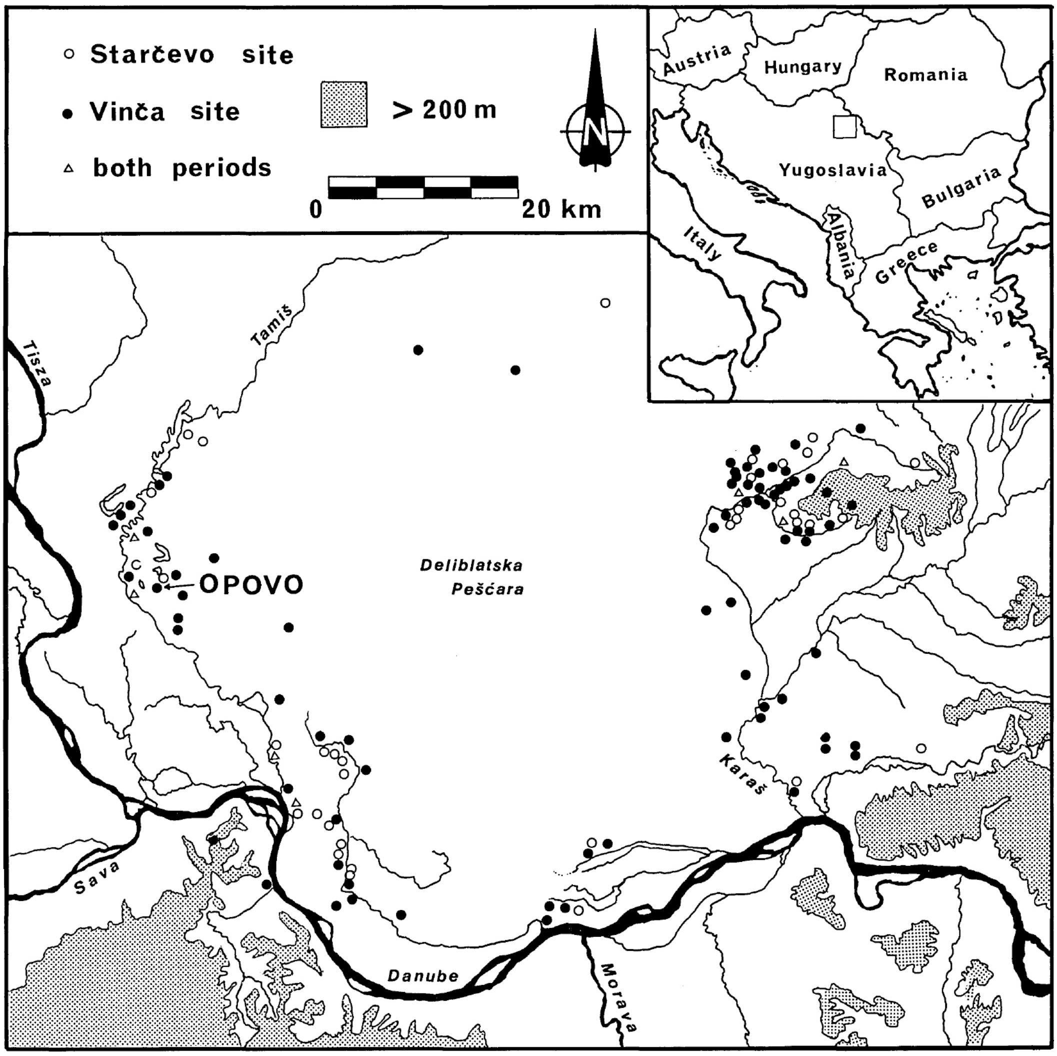

Fig. 2.9. Location of Opovo and other Neolithic settlements in the Banat plain (Tringham et al. 1992).

2.5.2 The origins of the Vinča culture

Neolithic settlements in the Banat began in the late 6th millennium BC with the appearance of Starčevo-Körös sites. The 5th millennium BC saw the 'transition'[3] from Starčevo-Körös to Vinča sites, which continued until the middle of the 5th millennium BC.

At the same time, in the northwest Banat and in the middle Tisza valley, there are sites with pottery similar to that of the Hungarian middle and late Neolithic cultures,

[3] See Chapman (1981) for an overview on the origins of the Vinča group.

Szakalhát and Tisza, respectively. With few radiocarbon dates and only a few small excavations, the Neolithic culture-historical sequence of the Banat is difficult to untangle (Tringham et al. 1992). Near Opovo, unsystematic surveys carried out by the National Museums in Pančevo and Vršac have resulted in the identification of 117 Neolithic sites, of which 39 are Starčevo, 64 are Vinča, and 14 are culturally mixed (Tringham et al. 1992, 354). Most of these sites are known from surface finds of ceramic and/or lithic materials, with less than 20% of the known sites having been excavated to any extent. Even with only 380 sq. m excavated, the largest Neolithic exposure in the south Banat is that at Opovo (Tringham 1985; Tringham et al. 1992).

Neolithic settlements in the south Banat are found in three clusters: 1) a dense cluster in the area around Vršac, near the Romanian border; 2) elongated clusters along the lower Tamiš River; and 3) along the Dunavac River[4]. There are also sites on or near the lower Karaš River and just north of the Danube. No sites have been found in the sandy plateau of the Deliblatska Peščara (probably used for hunting, see Chapman 1981, 96), the middle portion of the south Banat. Throughout the Neolithic, the most frequently chosen site locations were those on the loess terraces that border the river and stream courses of the Banat. Sites located near marshy ponds and oxbow lakes are also common. Only rarely have Neolithic sites been found on the loess plateau of the region. In the south Banat, Neolithic population aggregation was low (compared to Vinča sites south of the Danube) and settlement relocation appears to have been frequent in both periods. This perhaps is due to the fact that the area is characterized by frequent seasonal floods. These processes often resulted in linear distributions of small sites, extending over several kilometres (Tringham et al. 1992).

Over the course of the Neolithic, two major settlement trends are to be noted. The first one is towards higher settlement densities, which lasted at least until the middle of the Vinča period. Near the end of the Vinča period, settlement density began to decline. The other major trend in the Neolithic settlement patterns is the increase in site sizes, which likewise did not last longer than the middle of the Vinča period. Compared to sites from previous phases (FTN, Starčevo) and to those of the contemporary Linearbandkeramik, Vinča settlements are consistently larger. The degree of settlement nucleation can be appreciated by the fact that the largest Vinča site sizes exceeded most Near Eastern Early Bronze Age and Aegean Late Bronze age towns (Chapman 1981, 51).

As for settlement patterns, the lower Moravo-Danubian confluence region has not been systematically surveyed, so that only the two areas investigated yielded a sufficient number of sites to make a preliminary analysis (Chapman 1990).

First Temperate Neolithic sites (6th millennium BC) were initially located along major river valleys in order to take advantage of rich alluvial soils, thus leading to a sort of "linear" settlement pattern. After the invention of the ard, the so far neglected inter-

[4] Distributions of sites along river valleys have been discussed and modeled by Chapman for the lower Moravo-Danubian confluence area in the 5th millennium BC (Chapman 1990).

fluvial soils (such as Chernozem and Smonica) started to be exploited with the colonization of the tributary valleys; described as the "rational colonization" model by Chapman (1990).

Four main phases of settlement patterns have been proposed for this area:

Phase 1 (5200-4700/4600 BC) where site size is quite variable (from 0.2 to 12 ha) varying depending on the topographical location; smaller sites are located along stream-sides, whereas bigger sites are located on hill slopes. The variety in site locations (floodplains, riverside, stream-side, hill slope and plateau) indicates perhaps the exploration of a wider range of resources.

Phase 2 (4700/4600-4300 BC) when the number of settlements drastically decreases along with location variability, but this is most likely due to lack of discovery of sites.

Phase 3 (4300-4000/3900 BC) when the size of sites increases far more than anything seen before in Balkan prehistory, and Selevac starts becoming a central place for its macro-territory. The majority of sites in phase 3 are concentrated in the areas with the most fertile soils and some are located in the junction between uplands and lowlands, close to significant rock and mineral resources.

During *phase 4 (4000/3900-3300 BC)* the settlement pattern (incomplete) is quite similar to the one in phase 3, but with the significant absence of large central places. The settlement configuration during this period is of small villages and no sites resembling the size and complexity of Selevac (Fig. 2.10). Reasons for the decline of the Early Vinča hierarchical nucleated settlement pattern have to be found at a local and regional level (Chapman 1990).

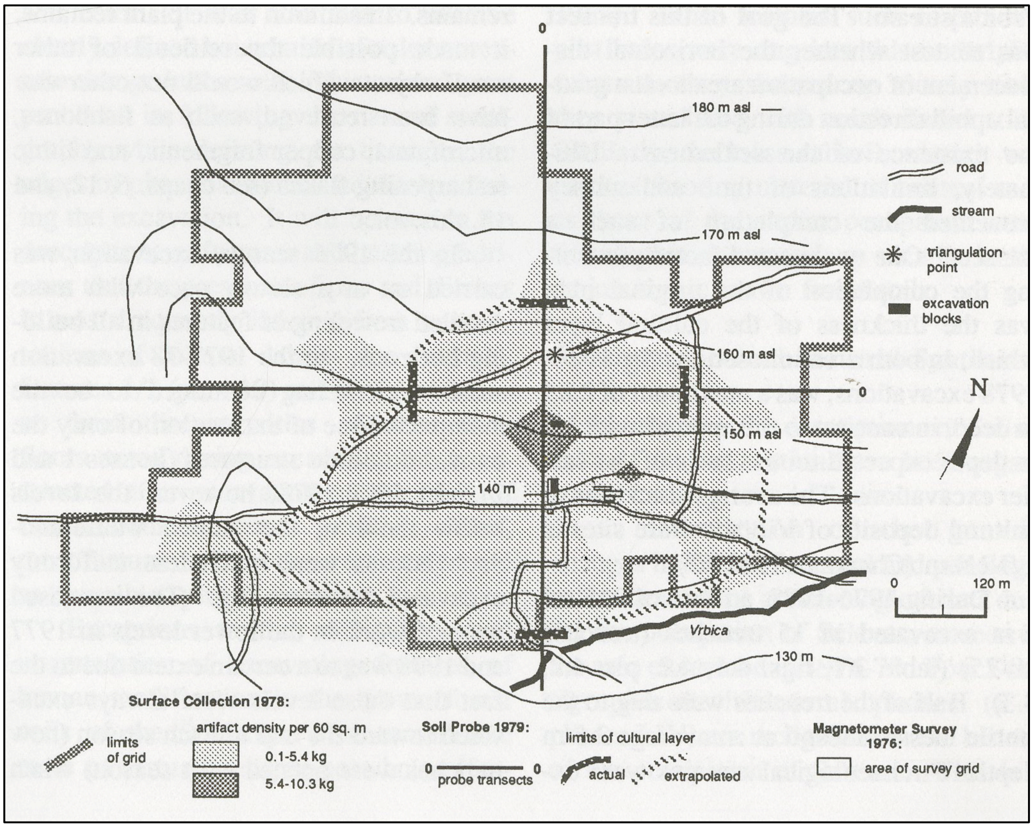

Fig. 2.10. Comparison of the results of surface and sub-surface survey at Selevac (Serbia), 1976-79. (Tringham and Krstić 1990, 75).

2.5.3 The end of the Vinča culture

The end of the Vinča cultural group, with the abandonment of the few remaining tell sites and large settlements, has been broadly debated. Special emphasis has been placed on the changes in material culture, burial customs and settlement patterns which occurred after the mid-5th millennium BC in the Central Balkans, as part of the transition from the Late Neolithic to the Copper Age. Early culture-historical explanations proposed the arrival of 'external' preformed cultural entities as the cause of the end of Vinča culture, such as the Proto-Tiszapolgár or Tiszapolgár culture groups identified by a new type of pottery production (e.g. footed beaker, pointed handles on a number of vessel types, the so-called "milk-jugs"[5] and a general use of high temperature firing). The development of copper mining and processing is generally seen as the main 'impulse' for the transition seen in the eastern Balkans, and the identification of burnt building horizons and consequent abandonment of Vinča sites has been construed as evidence of a 'catastrophic transition' (Bognár-Kutzián 1963; Bognár-Kutzián 1972; Tasić 1979; Jovanović 1995). A more processual-inspired explanation comes from scholars like Ruth Tringham, who worked at the sites of Opovo, Selevac and Divostin, which sees the end of the

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[5] For a critique on 'milk-jugs' see Craig et al. 2003.

Vinča cultural group as being caused by 'internal' social dynamics (Tringham 1992; Tringham et al. 1992; Tringham and Krstić 1990). According to these models population growth reached the threshold of carrying capacity in some territories, and that this stimulated the fission of part of the population. Once they had left the overgrown villages, they founded new flat settlements and established new social bonds with external neighbouring communities, with the household domain being the autonomous new core of social interaction. The weakening of old social ties and the development of new ones provoked a general fading of the Vinča social structure, this leading in turn to the final abandonment of large settlements. Post-processual narratives proposed by John Chapman and Ruth Tringham argue for the dominance, during the Early Copper Age, of the household domain as the primary social unit, something which is radically different from the interconnected and interdependent social life in a confined tell space. Moreover, Chapman argues for the establishment of an exogamous breeding network among the small farmsteads, along with the development of a competitive ideology based on the production and exchange of prestigious goods (such as metal objects), as hallmarks of the Balkan Copper Age (Chapman 2000c, 75). Furthermore, the shift from intramural burial towards extramural cemeteries is seen as a way of disassociating the newly deceased from the living, thus breaking the previous link between the living and their ancestors (Chapman 1996).

More recently, Borić (2015) proposed a neo-evolutionary model according to which culture changes are related to population dynamics and population bottlenecks (Shennan 2000), such as climate change and its impact on subsistence practices. Despite the lack of evidence for dramatic climate change in the mid-5th millennium BC in the Balkans, the abandonment of large sites and the pattern of dispersed settlements has been seen as a sign of population decline (even considering the research biases due to the poor visibility of Early Copper age sites). This is probably linked to a weakening of social ties (as suggested by Chapman) among the Vinča social network, caused by conflicts at a regional level (Borić 2015, 194).

All the different models are trying to explain this major change in settlement patterns after the mid-5th millennium BC in Central Balkans, where there is a radical abandonment of tell sites and large villages in favour of more dispersed small villages. Around the same time in the eastern-most fringe of Europe, in the Ukrainian forest-steppe, a remarkably different trend in settlement patterns is occurring with the development of Trypillia megasites. After approximately a millennium of strong nucleation these extremely large sites were abandoned in favour of dispersed small villages (see Chapter 6).

2.5.4 Okolište and the Bosnian Neolithic

More recently, the Visoko Basin, including the Late Neolithic tell site of Okolište, in central Bosnia, has been investigated by a team from the University of Kiel (Hofmann et al. 2008; Arponen et al. 2015). The tell-settlement of Okolište is located in the hilly mountains of Central Bosnia (Fig.2.1). The local cultural group is termed "Butmir culture" and dates to the Late Neolithic in terms of the local chronology (5200-4500 cal BC) (Müller-Scheeßel et al. 2009). The size of the tell gradually decreased over time. Thus, the settlement size was reduced from 7.5 ha around 5200 B.C. to 1.2 ha at around 4500 B.C (Fig.2.11). This change correlates with the development of the settlement pattern in the Visoko Basin and its surroundings: in the late Kakanj period, the settlements in the Visoko basin numbered about six. In the early Butmir phase the number decreased to four, which seems to imply a concentration of people in fewer settlements. This situation appears to have been stable until 4500 BC, even though the number of inhabitants of the largest site, Okolište, already started to decrease soon after the nucleation process.

At the end of the Butmir period, another significant change in the settlement pattern can be observed: long inhabited sites such as Okolište or Obre II were abandoned and a few new settlements were founded at the periphery of the Visoko Basin (Hofmann et al. 2008).

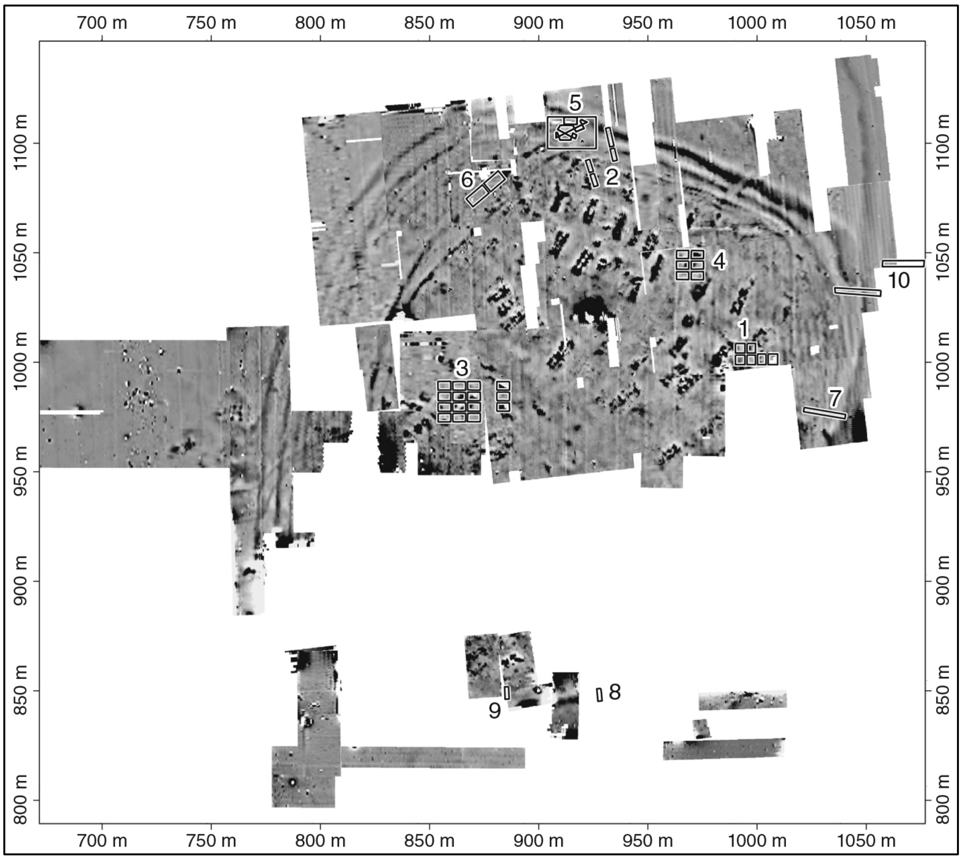


Fig. 2.11. Geomagnetic map of Okolište (Arponen et al. 2015).

2.6 Hungary

Hungarian archaeology has been active since the mid 19th century, but the first systematic archaeological survey was organized and funded by the Archaeological Institute of the Hungarian Academy of Science in the mid 1960s. The Hungarian Archaeological Topography project aimed to survey all the archaeological sites of the whole country and publish the results in a uniform format incorporating previous surveys in each administrative unit. The published volumes cover about 10% of the country in the form of eight volumes (e.g. Torma 1969, Jankovich et al. 1989).
The surveyed areas differ considerably in terms of geomorphology and hydrology, thus allowing quite accurate general conclusions and the interpretation of settlement patterns and overall site density in Hungary. The scope and the quality of the survey meet international standards, even though little theoretical and methodological background has been written and all the publications are in Hungarian (Chapman et al. 2010, 7). The Topography project stimulated new research which applied the new methodology, so that for big excavations an intensive field survey was carried out alongside in the surrounding area and gridded sherd collection was attempted on the main sites (e.g. Raczky et al. 1985).
A new type of research project has been developed - the "Microregion" project - in which investigative methods from the natural sciences have been applied to archaeology. This project was also influenced by new archaeological theories and approaches taken from abroad (processual archaeology, spatial analysis, site catchment analysis, etc.) and by collaboration with foreign scholars (Bökönyi 1992).
One example of the integration of topographic data into a broader socio-economical regional study in the Hungarian Plain was an Anglo-Hungarian project led by Istvan Torma and Andrew Sherratt. A new interest in social archaeology and the need of working at different scales of analysis came out of Sherratt's project; he compared different spatial scales of analysis for the Neolithic, Copper Age and Early Bronze Age in eastern Hungary, analyzed diachronic changes in settlement patterns in the Szeghalom area and intensive intra-site field survey data collection in each Early Neolithic, Later Neolithic and Early Copper Age sites (Sherratt 1982; 1983). The main results of Sherratt's comparative multi-scalar analysis are reported in Table 2.1.
Moreover, the introduction of Geographical Information Systems (GIS) in Hungarian prehistoric archaeology was a great step forward in the research discipline, especially when used as a unified platform to collate the results of the inter-disciplinary studies. The first project which made use of GIS was the Gyomaendrod microregional study, where a combination of different data, such as remote sensing, geophysics, palaeohydrology, geomorphology, pedology, physical anthropology, archaezoology and archaeobotany, were integrated in a single publication (Bökönyi 1992).

Dates cal BC	Archaeological group	Settlement patterns in the Szeghalom survey	Regional socio-economical changes
6000?–5300	Körös	125 sites identified along the riverine areas. Elongated shoreline sites (up to 2 km). Linear scatters of the bigger sites may represent settlement drift over generations (surely not a continuous built-up area). Maybe small sites temporary.	Cereal cultivation and seasonally available wild resources (e.g. fishing).
5300–5100	Alföld Linear Pottery (AVK)	95 sites found. Similar overall distribution with reduction in site sizes and different morphology compared to Körös. No aggregation, but small clusters.	Settlement distribution still predominantly riverine, although less reliance on fishing and wild resources and more emphasis on agriculture.
5100–4800	Szakálhát	29 sites. Phase of remarkable settlement agglomeration with fewer sites. 'Supersite' of Sártó (1800 X 400 m) is composed of individual concentrations of structures at 50 m spacing. Other aggregated tell-sites developed in the area, but to a smaller scale (10-15 km spacing).	"Supersites" are wealthy and interactions with uplands indicate an emphasis on other than cereal cultivations. High proportion of hunted animal and predominance of sheep as domestic stock. Evidence of trading with uplands.
4800–4400	Tisza	Process of aggregation increases and number of sites falls to 19. Continuity with three nuclei of the previous period. Subsidiary tells continue.	Crops probably cultivated in the vicinity of large sites if not in the intra-site 'empty' spaces. Signs of social cohesion, which is a stronger factor for aggregation than economic ones. Large sites sit on nodal river junctions probably for trading purposes. In fact, exchanges with uplands continue in this period.
4400–3900	Tiszapolgár	A bucking in the settlement trend sees a dispersed pattern of many (109) smaller sites. Small hamlets without internal compound or 'empty' space. Appearance of differentiation between settlements and cemeteries.	The separation of settlement and burial domain is one of the main hallmarks of this period, along with the trading of prestigious goods like copper axes. Economy still based on cattle breeding.
3900–3500	Bodrogkeresztúr	The landscape is almost empty with only few sherds found, although the pottery of this period is less diagnostics because of fewer decorations. The drop in site numbers is a genuine reflection of a drop in the population. However, the number of cemeteries increases 8-fold and so is the number of stray axes: the cemetery of Tiszapolgár-Basatanya contains 100 graves of this period.	While there is a clear shift towards the Danube-Tisza interfluve this area remains important for the remarkable presence of cemeteries.

Table 2.1. The table reports the main results of the analysis of the settlement dynamics and socio-economical changes in comparing the Szeghalom survey with the Great Hungarian plain (Sherratt 1982;1983).

2.6.1 The Upper Tisza Project

More recently in the mid 1990s, a large-scale Anglo-Hungarian project led by John Chapman and József Laszlovszky (the Upper Tisza Project) has incorporated multi-disciplinary and investigations in five published volumes.

The project included excavation and intensive fieldwalking in three micro-regions in North East Hungary: the Polgár lowlands, the Bodrogköz lowlands and the Zemplén Mountains (Fig. 2.12).

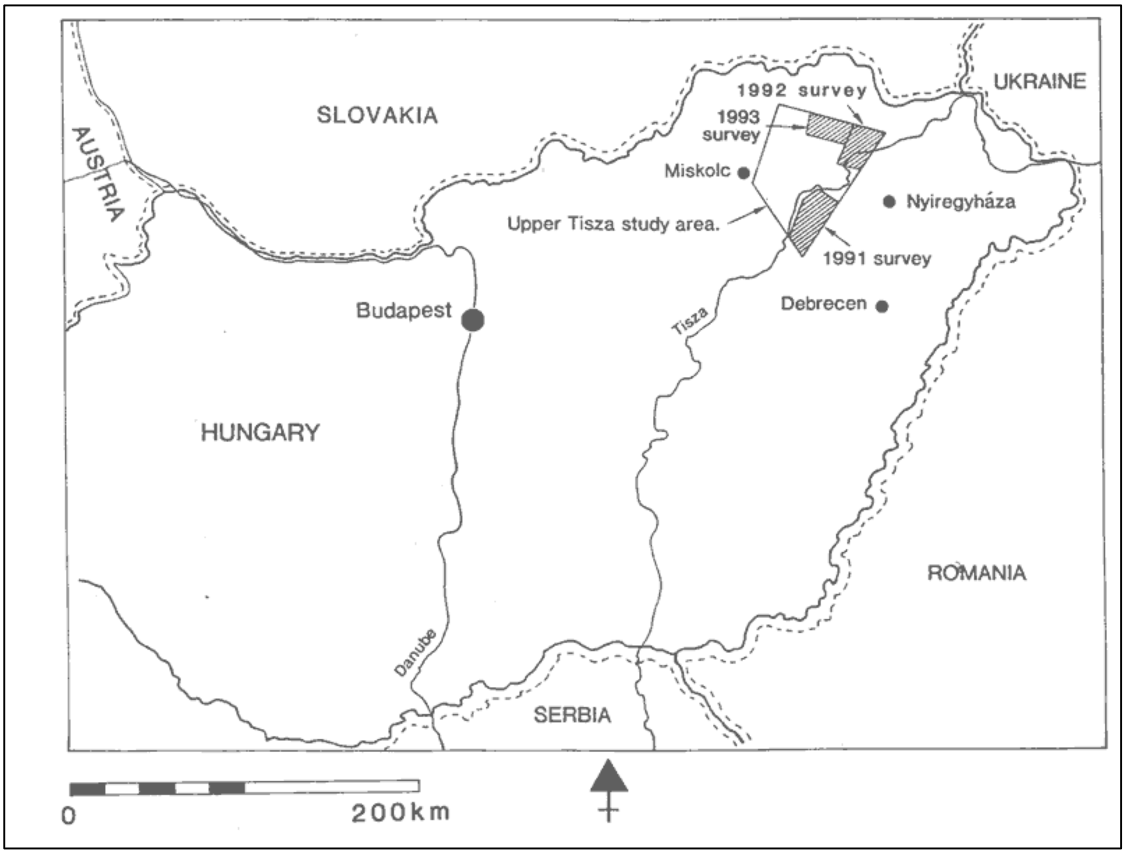


Fig. 2.12. Upper Tisza Projects survey areas (Chapman et al. 2010b).

The investigation of the three areas through fieldwalking and palaeo-environmental analysis has yielded insights on long-term settlement patterns from the Early Neolithic to the Modern Age (Gillings 1997; Chapman et al. 2010a; 2010b; 2010c; 2010d). The two lowlands areas of Polgár and Bodrogköz share similar overall settlement pattern, though with some differences in single finds recovery rate and site sizes for the periods in questions. After a few sites established in the Early-Middle Neolithic (5400–5200 cal BC), in both areas there is a peak in settlement densities during the Middle Neolithic (5200–4500 cal BC) when a variety of site sizes and site distributions has been recorded; settlements alignments along the edges of wetlands, and a number of flat-large sites (up to 48 ha – Polgár 046) surrounded by smaller settlements, tells (e.g. Csőszhalom) and tells with flat horizontal extension (e.g. Kenderföld) (Fig. 2.13).

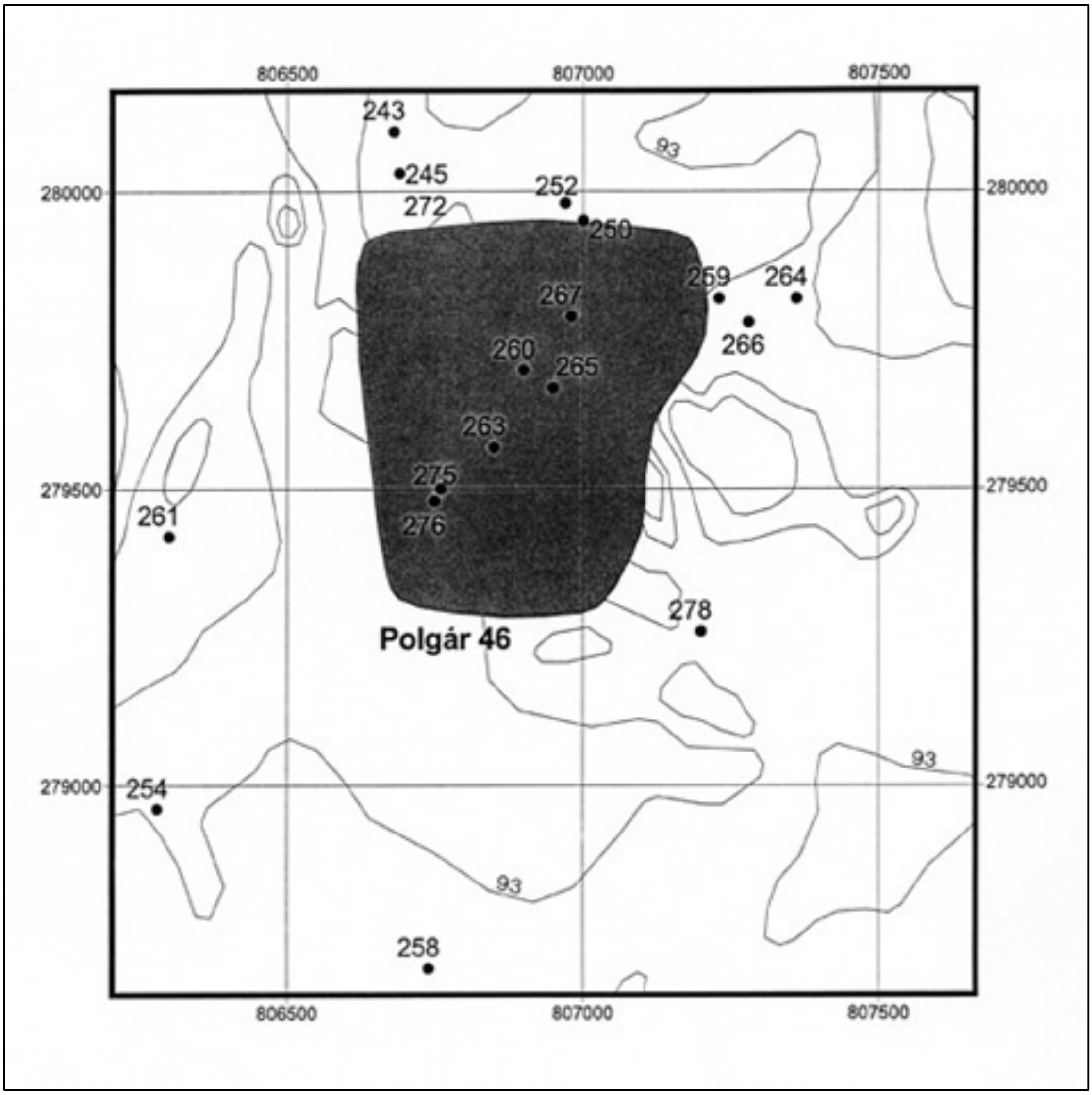


Fig. 2.13. Extent and settlement settings of Polgár 46 (48 ha). (Chapman et al. 2010b).

In Polgár, whilst the majority of the largest settlements have multi foci of material scatters (up to 4), thus suggesting an occupation by individual family units, the largest site of Polgár 046 with 14 foci could be seen as either a local central place or small hamlet to which small groups returned regularly. There is a marked contraction of the number of settlements in the Late Neolithic (4500–4100 cal BC), but settlement nucleation is also reported. In the Early Copper Age (4200–3800 cal BC) a reduction in sites number with a re-occupation of a few settlements from the earlier period characterizes the river terraces, whereas there is an abandonment of the floodplains. In the Late Copper Age (3500–2400 cal BC) the first burial mounds appear in the area and sites that were abandoned during the Early-Middle Copper Age are re-occupied.

Across the Bodrogköz region, though a much higher quantity of single finds has been found, mostly dating to the Copper Age (4200–2400 cal BC), whereas in the Polgár region the majority of the off-site scatters dates to the Neolithic period (5400–

4100 cal BC), thus suggesting a change in social-economic practices between the two areas (Chapman et al. 2010a, 217).
A similar settlement peak in the Middle Neolithic period has been attested in the Zemplén Mountains, although the evidence suggests only sporadic and temporary visits, to collect lithics and maybe hunting, from the lowlands with only a few upland “anchor” settlements. Throughout the Late Neolithic and Copper Age there is a complete absence of surface material both in the inner basin and the southern and western fringes.

2.6.2 Aerial Archaeological Archive

Between 1993 and 2006, The Aerial Archaeological Archive of the Institute for Archaeological Sciences of the Eötvös Loránd University of Budapest has carried out aerial archaeological surveys and processed the data obtained from the 768 aerial archaeological sites discovered in the whole country.
The project activities included the cataloguing of earthwork fortifications, tell settlements and tumuli, which has been greatly supported by photographical surveys. This survey revealed new sites as well as new information about already known sites (Czajlik 2007).

More recently, new technologies were introduced in to Hungarian archaeological research and survey techniques like Li.D.A.R. (Light Detection And Ranging) started to be used within two major survey projects: Aerial Imaging of the Wetlands of Lake Balaton and the Kis-Balaton and Archaeological and Relief Modeling of the Sárvíz-valley for Reconstruction of Ancient Climate Events, thus showing the willingness of employ the most advanced techniques in order to grasp a better understanding of the archaeological record (Padányi-Gulyás and Stibrányi 2011).

2.6.3 Körös Regional Archaeological Project

The Körös Regional Archaeological Project, directed by William A. Parkinson, Attila Gyucha and Richard W. Yerkes, has been conducting field investigations from 2000 to the present on the Late Neolithic / Early Copper Age Tiszapolgár transition in the Great Hungarian Plain. The aim of the project was to build a model of social organization for the transition between the Late Neolithic (5000–4600 cal BC) and Early Copper Age (4600–4000 cal BC) in region, by integrating a number of data sources; regional geomorphological studies, soil chemistry analysis, archaeological surface survey, remote sensing and systematic excavations at Early Copper Age sites in the Körös valley in southern Hungary. The multi-scalar (both spatial and temporal) approach led to a better understanding of this ‘transition’ as a more gradual process of social, economical and settlement patterns changes, as opposed to earlier interpretations that so it as an abrupt shift from a tell-based, sedentary, agricultural lifeway, to a mobile one based primarily on cattle herding (Bognár-Kutzián 1972; Jankovich et al. 1998; Raczy et al. 2002; Sherratt 1983; Parkinson et al. 2002). According to the results of the multidisciplinary and multi-scalar investigation, the development of new life-ways in the Early Copper Age, both in terms of settlement patterns and social-economic practices, occurred in different times and places. The transition from nucleated site clusters, in the Late Neolithic, to smaller and more numerous dispersed sites in the Copper Age has been observed at a regional scale for the Körös valley, where the number of sites increased sevenfold. At the local scale it was clear that these changes were associated with a transformation in the settlements layout (Parkinson et al. 2010; Guycha et al. 2013). More specifically, the Late Neolithic neighbourhood units, constituted by cluster of households within both flat and tell settlements, seems not to be found in the Early Copper Age (Parkinson 2002, 405-406). The neighbourhood unit that in the Late Neolithic constituted the basic unit of the site clusters become, in the Early Copper Age, the site itself.

Although there is an overall ‘transition’ from Late Neolithic to Copper Age, the ways this occurred are more complicated and dynamic than a simple abrupt shift in material culture, life-ways and settlement patterns.

2.7 Romania

The first activity of all Early Neolithic sites recording, in Romania, was begun by Gheorghe Lazarovici in 1984, when he found 131 sites across the entire country (Lazarovici 1984). Later, throughout the 1980s and 1990s he built up a relative chronology for the so-called Starčevo-Criş culture complex, based on pottery typology (Lazarovici 2005; for a comparison of different relative chronologies of Starčevo-Criş see Luca and Suciu 2011: Table 1). Afterwards, many surveys and researches have been published for different local areas but they lack of an overview of settlement patterns analyses (e.g. Draşovean 1981, Moga and Ciugudean 1995). Two major projects in the late 1990s and early 2000s brought together the known literature on Neolithic sites in Romania into an overall framework of settlement pattern for the region.

2.7.1 The Southern Romania Archaeological Project (SRAP)

Since 1998, the Southern Romania Archaeological Project (SRAP), led by Douglass Bailey, has been investigating a small area (8 sq. Km.) of the Neolithic landscape in the Teleorman valley (Fig. 2.14). The fundamental aims of SRAP are to refine and deepen the knowledge of the record of settlements and landuse in southern Romania. The Project started from an understanding of Boian culture material found at the bottom of the Teleorman valley, expanding to the reconstruction of the whole Neolithic sequence of the valley, including the Criş, Dudeşti and Gulmeniţa cultures. The project made use of a GIS platform to store all the data coming from different sources, excavation, fieldwalking, geomorphology, and topography.

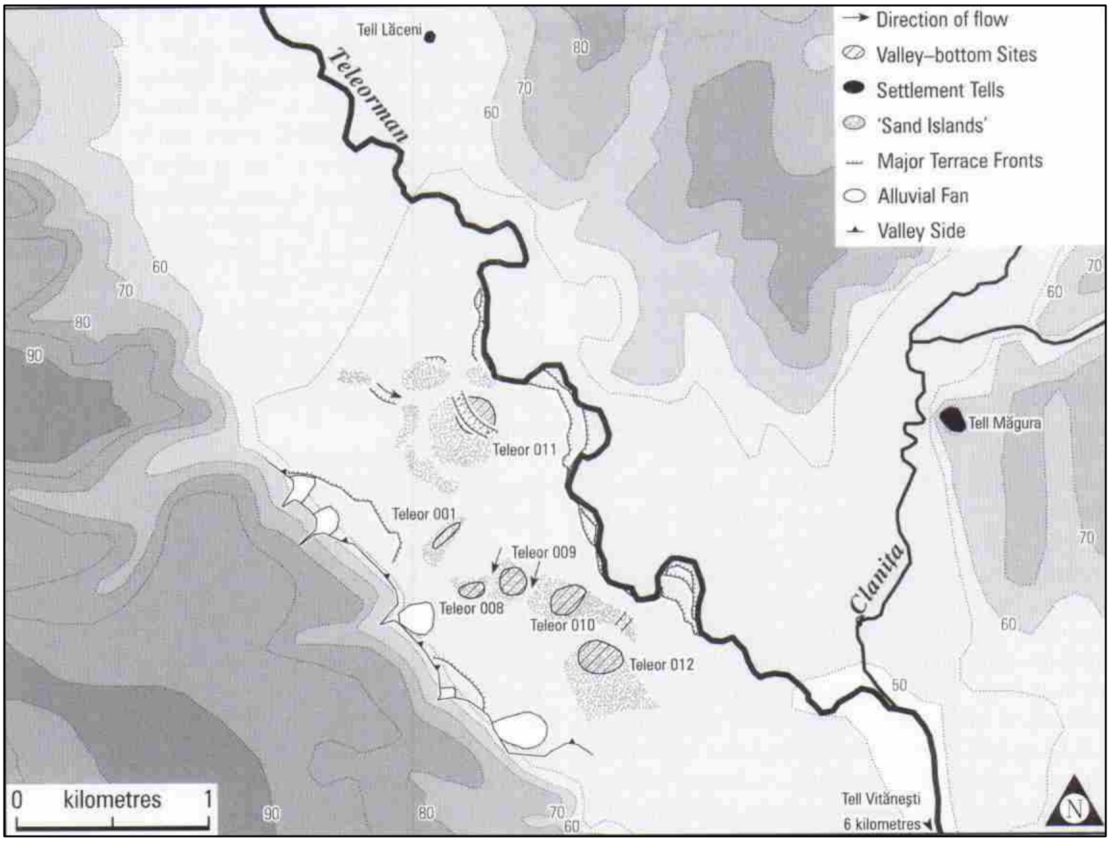


Fig. 2.14. SRAP project survey area. Boian Culture sites, geomorphologic features and tells at Lăceni-Măgura (Bailey et al. 2002).

The multidisciplinary approach led to important preliminary results; the geomorphological analysis provides a possible explanation of the shift towards permanent tell settlements in the 5th millennium BC (Bailey et al. 2000; 2002).

Geomorphological investigations showed that the Neolithic Boian sites in the Teleorman valley were located on sandy dunes at the valley bottom, thus showing an overall environmental instability at that time that explains the ephemerality of these settlements, which were most likely seasonal occupations (Haită 2002). During the succeeding Copper Age Gulmeniţa phase people settled on tell sites located on gravel bars at the edge of the river valley in the first unflooded strip of land. This guaranteed more stable settlement conditions that supported large-scale, field-based agriculture (Bailey et al. 2000; Howard et al. 2004). However, Bailey et al. (2002) suggest that the 'shift' to tells, in the Lăceni-Măgura area, is not prompted by hydrological changes (more stability) of the Teleorman River, as the reason why Gulmeniţa people started to live on gravel bars was because of the instability of the river. Bailey et al. (2002, 354) argue that people wanted to continue to live by the river, but in a more permanent (and probably safer) way.

2.7.2 The Formation of Europe: Prehistoric Population Dynamics and the Roots of Socio-Cultural Diversity (FEPRE project)

Since the early 21st century the FEPRE project (The Formation of Europe: Prehistoric Population Dynamics and the Roots of Socio-Cultural Diversity) started an intensive recording program of all the sites in Transylvania, Banat, Oltenia and Western Muntenia (Luca et al. 2011). A database has been created with all the Early Neolithic sites known from literature and if necessary re-survey them and plot using GPS and incorporate radiocarbon dates where existent. The Starčevo-Criş database recorded within the FEPRE project yielded 320 sites for the regions taken into consideration (Luca et al. 2011, 8-9). The project established a new chronology for the Starčevo-Criş culture on the basis of new radiocarbon dates and the pottery typology by Lazarovici (1984) and proposed an old-fashioned diffusionist hypothesis of Starčevo-Criş migration towards the north.

Starčevo-Criş Phase I (6100/6000–5900/5800 cal BC); sites are mostly from Transylvania, one from Banat, one from Muntenia, and the dates are coeval to Early Neolithic sites like Chavdar, Karanovo and Polyanitsa in Bulgaria (Boyadzhiev 2009).

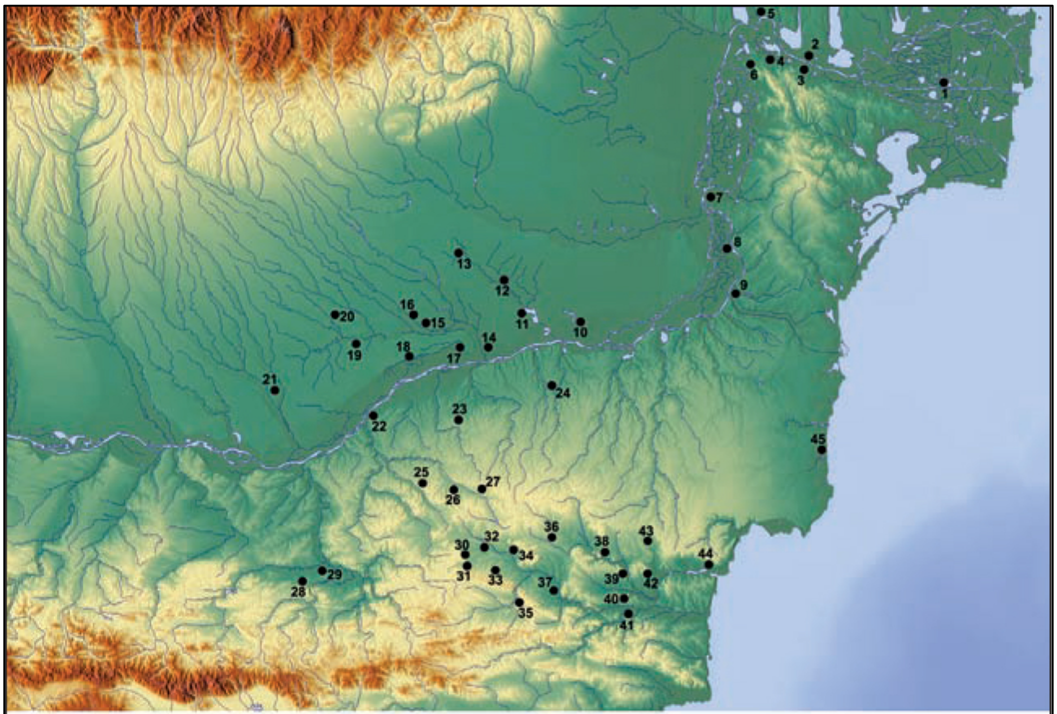
Starčevo-Criş Phase II (5950/5850–5800/5700 cal BC); the number of sites increases in the Middle Mureş valley and the Banat area as well as southern Oltenia are fully settled.

Starčevo-Criş Phase III (5800/5700–5600/5500 cal BC); the area of northwest Transylvania is settled during this phase along with Someş and Barcău river valleys.

Starčevo-Criş Phase IV; the start of Phase IV is seen as unitary at around 5600/5500 cal BC, but the end varies by regions as at this point Vinča material start to appear in different areas. The presence of Vinča communities along the Danube and southern Transylvania is seen, by Luca et al. (2011), as the cause of a decrease in the number of Starčevo-Criş sites in the Middle Mureş valley, Banat and Oltenia. The number of Starčevo-Criş settlements is, instead, increasing along the Someş and Barcău river valleys and eastern Transylvania.

2.7.3 The Copper Age tell site of Pietrele and the Lower Danube region

Whilst at around 4500/4400 BC in most of southeast Europe tell sites were abandoned, this settlement form was introduced in the Lower Danube region, with tells like the Copper Age Gumelniţa Măgura Gorgana (near the modern town of Pietrele) at around 4700/4600 BC (Fig. 2.15).



1. Taraschina, **2.** Orlovka, **3.** Isaccea, **4.** Luncaviţa, **5.** Giurgiuleşti, **6.** Carcaliu, **7.** Hârşova, **8.** Borduşani, **9.** Cernavodă, **10.** Cuneşti, **11.** Sultana, **12.** Şenoiu, **13.** Măriuţa, **14.** Gumelniţa, **15.** Vărăşti, **16.** Vidra, **17.** Căscioarele, **18.** Pietrele, **19.** Tangâru, **20.** Bucşani, **21.** Vitănești, **22.** Ruse, **23.** Kubrat, **24.** Sokol, **25.** Golian Izvor, **26.** Hisarlik, **27.** Radingrad, **28.** Hotnica, **29.** Samovodene, **30.** Poljanitsa, **31.** Omurtag, **32.** Nevski, **33.** Ovčarovo, **34.** Loveč, **35.** Vinica, **36.** Kodžadermen, **37.** Smjadovo, **38.** Slatina, **39.** Provadija, **40.** Sava, **41.** Goljamo Delčevo, **42.** Devnja, **43.** Suvorovo, **44.** Varna, **45.** Durankulak

Fig. 2.15. Map of the Lower Danube region with sites from the Gumelniţa culture (Benecke et al. 2013 ©DAI, Eurasien-Abteilung, Pietrele Project).

Currently available data suggest that the tell was erected prior to 4600 cal BC, but only a fully excavated sequence could bring a more accurate estimation for the initial phase (Benecke et al. 2013). Nonetheless, the flatland settlement surrounding the mound was in occupation well before the construction of the tell and then abandoned with it at around 4250 cal BC (Benecke et al. 2013, 181). The oldest dwelling of the flat settlement dates back to the last two centuries of the 6th millennium BC and in the northeast part Boian pottery has been uncovered in association with some habitations; although the radiocarbon dates for the layers containing Boian pottery are still under process the style can be assigned to the beginning of the 5th millennium BC (Hansen et al. 2015). Faunal remains from both Late Neolithic Boian layers in the flat settlement and from Copper Age Gumelniţa contexts on the tell, allowed for a direct comparison between the two quite different management systems for animal resources (Benecke 2004). The Boian settlement's economy is mostly based on agriculture with hunting playing a minor role. Animal husbandry is mainly focused on cattle. Conversely, the faunal remains from the

Gumelniţa contexts suggest that wild animals were the main source of food, with only half of the discarded bones coming from domesticated animals. Equally, fishing activities played a major role in the Copper Age economy at Măgura Gorgana (Bartosiewicz and Bonsall 2004). Based on radiocarbon dates and Optically Stimulated Luminenscence (OSL) dating, a body of water (lake) has been located in this region, providing an economic resource between the 8th millennium BC and the 1st millennium AD - time when it was drained (Benecke et al. 2013). While the Late Neolithic Boian culture economy was mostly based on agriculture, despite the presence of the lake, during the Copper Age (after 4600/4500 cal BC) a specialized hunting and fishing subsistance developed at the site near Pietrele and surroundings along with the construction of a mound settlement. More landscape-based research on this time period across the region and other comparable geomorphological settings would help in understanding such radical changes in the economy between the Late Neolithic and Copper Age.

2.8 Ukraine

The literature on the Neolithic, Eneolithic, and in general on the archaeology of the Ukraine, is still mostly influenced by the cultural-historical tradition and mostly published in Ukrainian and Russian, although in recent years a number of publications on radiocarbon dating are started to appear (in English: Telegin 1987; Telegin et al. 2002; 2003; Dolukhanov et al. 2005; Rassamakin and Menotti 2011).

The 'transition' Mesolithic – Neolithic is still unclear and the historical explanations are still linked to a diffusionist and Childean perspective (Zvelebil and Dolukhanov 1991). Zvelebil and Dolukhanov (1991) argue for an initial aceramic phase of the first acknowledged Neolithic culture - Bug-Dniester (5500–4900 BC) – together with a ceramic later phase (4900–4400 BC). Evidence for agricultural practices has been found for Bug-Dniester culture and contacts with Starčevo-Criş, based on farming knowledge transfer, have been argued by Tringham (1971; 2000), Zvelebil and Lillie (2000), Pashkevych (2012). On the basis of a new set of radiocarbon dates, Telegin et al. (2003) argue for an earlier start of the Bug-Dniester culture on the northwestern littoral of the Black Sea at the mid-7th millennium BC. Subsequently, towards the mid-6th millennium BC the Bug-Dniester population are, according to Telegin et al. (2003), 'integrated' with the Early Trypillia.
Similar, the start for the Trypillia phase A is proposed by Boyadziev (2005) at around 5700 bp from the site of Timkovo.

2.8.1 Cucuteni-Trypillia

At this point the discussion will turn into the main archaeological group, which is the topic of this research, the Cucuteni-Trypillia. This complex is defined by the following traits: (painted pottery, figurines), building techniques (wattle and daub rectangular dwellings), settlement plans, mixed farming economy, social organization (lack of social hierarchy), practice of house-burning (a predominance of the household domain), and almost total lack of mortuary domain. The group extends from the Carpathian Mountains, in modern Romania, to the Dniester region (in Moldova) to the Dnieper basin in Ukraine, thus covering an area of approximately 250,000 sq. km (Fig. 2.16).

Fig. 2.16. Areas of influence of the Cucuteni-Trypillia group in relation to other adjacent archaeological cultures.

Despite sharing a number of features, only the Trypillia (Ukrainian) part of the whole group, developed extraordinary large settlements (megasites, see Chapter 1) that started to appear and concentrate in the Southern-Bug/Dnieper interfluves from the end of the 5th millennium BC.

The "megasites phenomenon" has been considered as a research topic ***per se*** somehow separate from the development of the Trypillia group and certainly the dynamics of the megasites as specific form of settlement deserve special attention, but also integration with the rest of the coeval settlement patterns, which will be broadly discussed in Chapters 5 and 6.

2.9 Enclosures

Enclosures deserve a particular mention as a settlement feature that characterized a number of settlement forms across Europe since the Neolithic. The development of enclosures is associated with a variety of social and political implications (Parkinson and Duffy 2008). Particularly in recent years their visibility as archaeological features increased thanks to the application of geophysical techniques that aided their detection and mapping on a broader scale. Examples include from a Late Neolithic tell (Borđoš) in northern Serbia (Banat), which is constituted by a complex of an enclosed flat settlement and a mound (Medović et al. 2014), as well as from the southeastern Hungary Early Copper Age fortified hamlets of Vésztő-Bikeri and Körösladány-Bikeri (Yerkes et al. 2007) (Fig. 2.17-18).

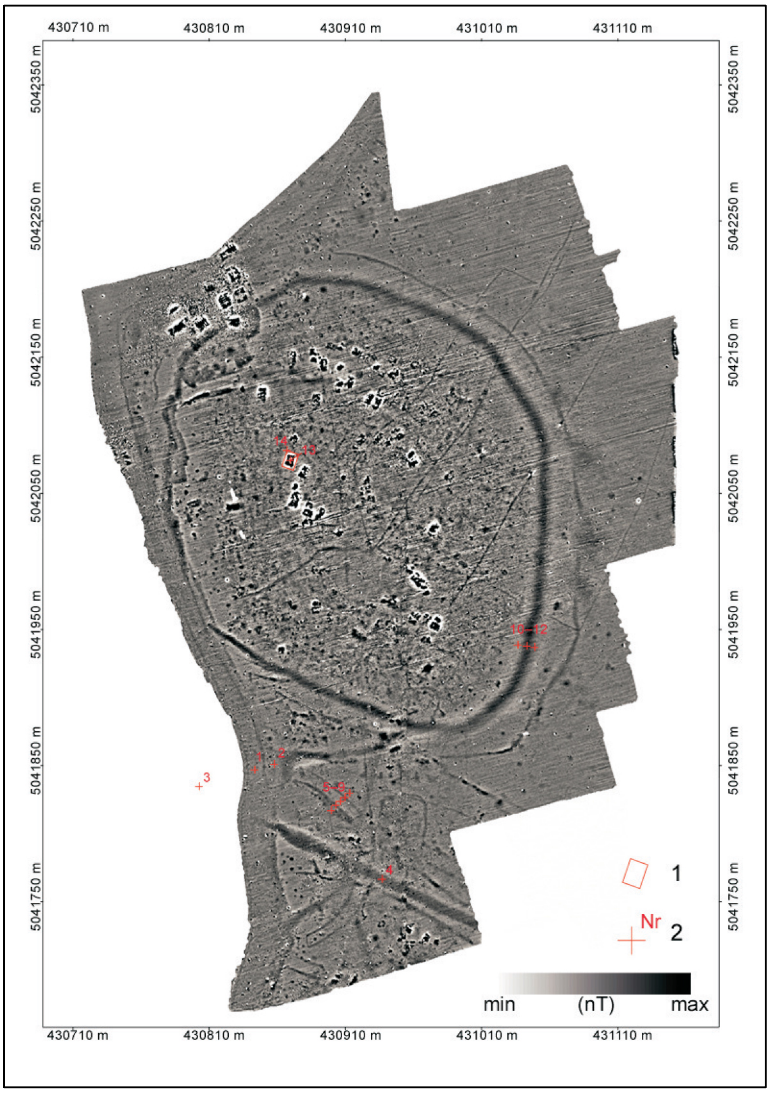


Fig. 2.17. Geophysical plan of the Late Neolithic tell of Borđoš, Serbia (Medović et al. 2014).

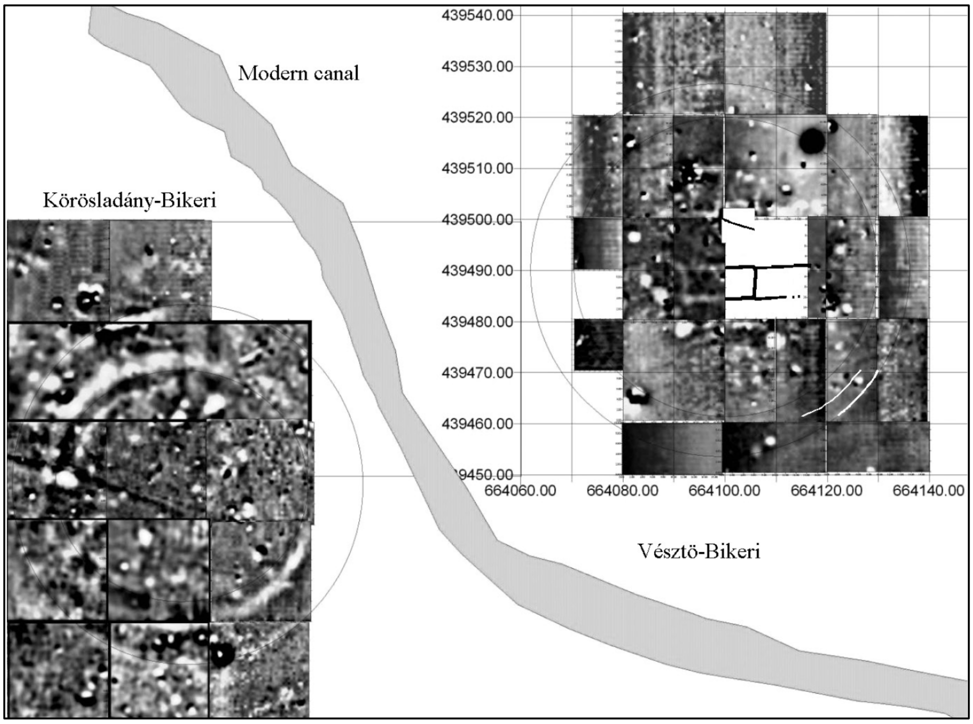


Fig. 2.18. Geomagnetic plans of the Early Copper Age fortified hamlets of Vésztő-Bikeri and Körösladány-Bikeri (Yerkes et al. 2007).

The relevance of this topic to my overall research questions is related to the fact that enclosing ditches have been recently found at some Copper Age Trypillia sites in Ukraine (Chapman et al. 2014b; 2014c; Rassamann et al. 2014; 2016). The presence of a perimeter ditch at the Trypillia megasite of Nebelivka has been interpreted in two radically different ways: as part of a fortified palisade (Burdo and Videiko 2016) or as a simple relatively shallow ditch (Chapman et al. 2016).

The significance of the ditch as a settlement feature in the making of the megasite-place and its social implications will be discussed in Chapter 6.

2.10 Concluding remarks

Overall, the discussion of the settlement dynamics of the Balkans between the Neolithic and the Copper Age has prompted a number of themes that are worth teasing out for comparison with the case of Trypillia megasites - the main focus of this doctoral research. These can be identified as; 1) the making of and development of the place-value of specific settlement forms such as tells; 2) the co-existence of aggregated tells and flat-sites and their socio-economic interactions; and 3) processes of settlement aggregation and dispersal.

The process of tell formation is closely related to the development of settlement aggregation that occurred in the Balkans at different times and in different areas. One of the earliest regions to have seen the development of such settlement form is

the one occupied by the Vinča group at around the end of the 6th – beginning of the 5th millennium BC. Additionally, by the 51st century BC in both northeast and southeast Hungary, there is an increase in the number of sites along with a remarkable development of larger settlements including tells. In the 5th millennium BC, Romania (Teleorman Valley) and North Bulgaria also saw the development of such settlement form. Only later, at around the 47th century BC, in the Lower Danube region near the border between Bulgaria and Romania, tell settlement started to appear (e.g. Pietrele). Alongside the development of tells, the settlement patterns change in different ways; in some areas, like southeast Hungary, the development of tells corresponds to a decrease in the number of sites, thus indicating a process of nucleation and abandonment of some previously settled areas. Conversely, in the Vinča territory, as well as in North Bulgaria, the development of tells is accompanied by a general increase of site numbers, with tells and large flat-sites being local central/anchor places of a modest, two-level settlement hierarchy. However, in some cases, such as the Moravo-Danubian confluence zone, there is a drastic decrease in site numbers (although this is probably due to the paucity of fieldwalking). However, in this area, the size of sites increases like never before in the Balkans, with the development of settlements like Selevac (65 ha) Nevertheless, a common trait of tell formation is the 'landmarking' of a particular space, with repeated house building in the same spot, thus emphasising its ancestral value (Bailey 1999). Different social dynamics led to the development of these diverse settlement systems, and dissimilar social interactions were characteristics of the different settlement forms. A higher social cohesion in compact tell settlements is suggested by the prevalence of the neighbourhood domain over the household one. Looser social ties can be proposed for small hamlets or farmsteads, where the family and household independence is predominant.
The interactions between coeval tells and small sites has been interpreted as primarily economic, as in the case of Podgoritsa, where the investigation of the areas surrounding the tell recovered a number of flat-sites construed as workshops. It is quite clear that the limited range of economic activities that can be performed on tell sites (Chapman 1989) necessitated interrelations (long- or short-range) with other forms of off-tell site.

By the middle of the 5th millennium BC, in most of the central-western Balkans there is an abandonment of tells and large sites in favour of dispersed patterns of smaller settlements. In some cases, this corresponds to an increase of the number of sites, as in northeast Hungary, as well as re-occupation of previously abandoned areas. The abandonment of tells has also been seen as the abandonment of a settlement form, but not of the settlement as a place. This is analogous to the case of the Körös Valley, where household clusters were replaced with household units, thus marking the ancestral significance of the place (Parkinson et al. 2010). A completely different trend is attested in the Lower Danube region, where tell formation developed only two centuries before the general abandonment of this settlement form in the rest of the central Balkans. The variability of tell abandonment dynamics suggests a similar variety of socio-economical drivers that prompted this change in different regions. Only more fine-grained and accurate radiocarbon dates will help in teasing out the different trends at local and regional scales.

Overall processes of settlement nucleation and dispersal are attested across Balkan prehistory, occurring earlier in the southwestern regions and rather later in northeast ones. Similar settlement dynamics of nucleation and then dispersal can be found almost a millennium later in the easternmost fringe of Europe, in the Ukraine. However, the reasons for these processes are to be sought within the context of coeval settlement patterns and not simply applying models that have been proposed for the rest of the Balkans.

The key themes that have driven the settlement history of the Neolithic Balkans and that can be taken into a direct comparison with the Trypillia world mostly regards, 1) the making of places and the development of place-value in relation with the emergence of new identities within the formation of new settlement forms, 2) and the processes of settlement nucleation and dispersal.

Comparable mixed economy, material production, architecture, and overall settlement forms can be found in all the regions discussed in this chapter and in the Trypillia group. However, only the latter sees the development of the biggest settlement in Europe at that time so far known. Megasites are the key aspect of the Trypillia group that require investigation in order to understand what social and economic dynamics developed specifically in Ukraine in the 4th millennium BC.

Chapter 3: Quantitative narratives: scale, data and tools

3.1 Introduction

This Chapter will delineate the theoretical framework adopted in the research, which derives from an overall ***Landscape*** approach to the study of Trypillia megasites and urbanism in general. It will start with an overview on ***Landscape Archaeology*** and point out which theoretical aspects will be undertaken in order to develop a bespoke and nuanced critical path.

3.2 Theoretical overview: scale and units of analysis

Over the last few decades, Archaeology as a discipline has devoted its research focus increasingly on gathering a deeper awareness and knowledge of what constitutes the "archaeological record" (see section 3.5 for a detailed discussion on archaeological record and data). This has meant going beyond the site/excavation limits, towards a dense – rather than discrete – conception of archaeological record, thus considering every element/***feature*** built by human actions as a result of certain economic and social strategies. The best description of this approach is provided by Martin Kuna's (1991) concept of 'community areas' that emphasises all the off-site activities that leave apparent 'empty spaces', which need investigating in order to understand the whole scenario of socio-economic activities that shaped the landscape.

In order to describe and to provide a better understanding of past human life and development, it is fundamental to rely on any element that has survived to date and try to interpret and reconstruct a complex scenario made of fragmented clues which can be detected and analysed by archaeologists. The term ***Landscape Archaeology*** should be considered more as ***Archaeology*** tout-court*,* rather than a specific branch of the general discipline; it conceives the archaeological record as a cumulative palimpsest of different traces/elements/agents, whose interaction impacts on the overall system (Bentley and Maschner 2003, 5). ***Landscape Archaeology*** developed its own theoretical and methodological research agenda, but considering its embedded spatial nature, we may see its applicability suitable for a variety of sub-disciplines. The archaeological residuals reflect the non-linear development of ancient society's complexity and the aim of archaeologists is to untangle such deposit of traces in order to track down major cultural, social-economic trajectories and understand their "evolution"[6]. Human societies can be conceived as Complex

6 The term 'evolution' is used here for its temporal meaning only.

Adaptive Systems (CAS), where an ensemble of entities are linked to one another and interact in different ways, ranging from static relations to more dynamic ones (Miller and Page 2007; Smith et al. 2012). The different parts/entities of a complex system interact in non-simple ways and by analysing and interpreting the properties of these interactions, it is possible to infer the properties of the whole (Simon 1962, 468). These entities are nested in sub-groups that are structured in organized hierarchies, and the complexity of the CAS increases as the sub-groups nesting grows. Interactions among the component ***intra*** sub-groups are more frequent than those among component ***inter*** sub-groups; therefore, the level of hierarchy inside the sub-groups increases quicker than the hierarchical level of the whole system.

In the study of the urban development we can conceive the household as the smallest component of a settlement, which, in turn, constitutes the sub-group level of a CAS. The organizational hierarchies are established within a settlement function even if the site loses its interactions with other sub-groups, although the loss of linkages between higher level entities can affect the way CAS develop and collapse (Barton 2014, 307-308). According to Simon (1962) CAS tend to grow as lower level entities merge into groups, which join into higher-level meta-groups, thus increasing their organizational complexity. However, the level of hierarchy develops from social groups (lower level) which have an internal organization already (Simon 1962).

Overall, it is more the magnitude and properties of the interactions between lower level entities than the inherent characteristics of the CAS that defines its behaviour. Therefore, only an accurate investigation of sub-groups and their relationship with each other can provide a glimpse to understand the piecemeal archaeological record.

In this view, households, neighbourhoods, villages and megasites are the units/sub-groups of analysis whose interactions have been investigated and the fundamental social role of their interplay highlighted.

From an archaeological perspective, the palimpsest of traces that ancient societies left on the ground is the result of complex social-economic scenery, which evolved behind its formation. Each human action could have built a piece of landscape representing, among others, an economic activity such as agriculture, pastoralism, mining or water management. All these are ***elements/objects*** which form a complex system (Von Bertanlaffy 1968) within a connectivity network supporting a number of social practices and channelling the flow of various sources of information/energy/resources. Not all "objects" are still visible and detectable, however by analysing the full spectrum of possible residual evidence by means of a number of fine-tuned heuristic devices, we can refine the reconstruction of the encompassing system, or at least gain a better understanding of it. In this view, if we look at the landscape as an archaeological deposit, we can define a vertical stratigraphy that follows Harris-like rules (Harris 1979) where different patterns are assumed as stratigraphic units which show a number of topological relations (such as cutting/superimposition) that could be recovered, to some extent, by remote sensing and field survey, even from the plough-zone medium (De Guio 1992; De Guio et al. 2009). Moreover, a horizontal stratigraphy can be outlined by detecting cycles of expansions and contractions in the living space due to a variety of "zonation and tactical mobility" settings, acting on both ***site*** and ***off-site*** domains as structured by a time/space/function -sensitive connectivity. The main goal of this approach is to differentiate the elements of the palimpsest of ***marks*** and ***features*** in order to achieve ***pattern recognition*** of different phases of the layered "relic" landscapes. This aids in understanding which are the main characteristics of each phase, and seeks to establish and explain the way they changed, continued or collapsed.

The complexity of different archaeological patterns has to be tackled from various perspectives in order to analyse it thoroughly. The study of sub-groups, their structure and interactions is translated into the investigation and interpretation of the archaeological record at different scales of analysis. The ***intra-site*** domain encompasses the sub-group level of complexity which is considered as an object of study itself; the range of structural and hierarchical dynamics occurring during the site formation and development bring to light a number of organizational trends proper of the households (smallest entity) interactions. The administration of a site is the first example of social organization of a human society and reflects, but may not be dependent on, the whole societal system. The ***inter-site***/regional domain, represents the interaction and organization of different sub-groups, but the development of a social structure at this level doesn't necessarily reflect the social complexity of the individual sub-groups. Regional systems can, in fact, evolve into new behaviours unrelated to behaviours associated with the sub-group, thus causing a phenomenon called ***emergence*** (Barton 2014, 309). An example can be seen in the house building process, where none of the individuals has the knowledge to build it by himself, but the organized interaction of a number of entities/individuals can finalize a complete and functioning dwelling. A larger scale example is given by the Körös Regional Archaeological Project discussed in Chapter 2 where although there is an overall "transition" from Late Neolithic to Copper Age, the way this occurred are more complicated and dynamic than a simple abrupt shift in material culture, life-ways and settlement patterns (Parkinson et al. 2010).
The traditional way of formulating archaeological narratives as sharp changes in the social-economic life, political life, and pottery production has been now replaced with more elaborated interpretations of transition processes. Archaeologists have been trying to overcome the limitation of a piecemeal and partial archaeological record, which often prompts simpler and more straightforward interpretations of what has happened. Moreover, new methodologies spurred the development of new

research tool-kits that embody not only the mere technique but also the underpinning theoretical framework.

One way to handle this type of data within a single framework of analysis is represented by Geographical Information Systems (GIS), which are the best tool/***medium*** that allow for storing and representing the archaeological record, thus highlighting its dense and continuous nature in the space. GIS contain spatial information and can represent, in a rational and dynamic way, different sorts of data that can be compared and integrated.

3.3 Geographical Information Systems (GIS)

Although this tool has been 'borrowed' from other disciplines – such as Geography and Environmental Sciences - archaeologists should address the specific problems of storage, representation, visualization and analysis of archaeological information and move towards a development of a more bespoke and customized Archaeological Information Systems (AIS) (Llobera 2011). Some scholars criticized the use of GIS in archaeology as it cannot convey a thorough understanding of the meaning archaeological remains had for people in the past; GIS are only a way of representing archaeological data but they don't help understanding the archaeological remains (Tilley 2004, 218). Others deem that GIS are incapable of representing the experiential aspects of the world, particularly of the past, and accuse the mapping exercise of reducing the "reality" into a limited Cartesian system (Thomas 2004). Other archaeologists, more favourable of the use of GIS for their discipline, consider its great potential for the analysis of archaeological record and its capability of framing this tool into different and more interpretative theoretical approaches, thus deeming GIS mostly as a customizable tool rather than it being the only aim of the research (Llobera 2012, 219). Other GIS users suggested not trying to build a bridge between phenomenologists and experientialists and GIS users, but rather conceptualizing new theoretical frameworks within the use of GIS such as investigating the experiential affordance of the landscape (through the analysis of the influence of its physical components on human life-ways), rather than trying to model the human perception of it (Gillings 2012).
I think that GIS can be conceived, at different levels, as a tool for the archaeological research. It can simply be considered as a data storage system, a database, which is more suited for spatial information, such as archaeological data, thus leaving out the interpretative potential of it. A second level could be represented by the use of all the GIS spatial analysis tools to embrace a structural-processual approach to the data and landscape studies; thus considering the archaeological information within a system theory framework, where perception, experience and personhood have a minor role in the formulation of historical narratives. A third level could be identified in

Gillings (2012) approach to the matter, where a theoretical framework is conceptualized in light of GIS capabilities as well as limitations. The point here is to prioritise and plan the workflow.

Given the variability of archaeological information, in terms of availability, typology, accuracy, resolution and recording methods, the choice of a bespoke toolset (both theoretical and methodological) has to be based on the data. Different data conditions can lead to the adoption of different theoretical approaches, research questions and methodologies.

For its spatial nature, GIS embodies the best set of capabilities used in ***Landscape*** studies, as it allows for a dynamic view of the archaeological data at different scales of analysis, thus aligning with the research critical path that aims to understand and untangle the complexity of human society's history. Multi/Inter-scalar approaches have been recently adopted by the archaeological research, in order to tackle large but uneven and piecemeal datasets (Bevan 2012) and to fully understand the complexity of human interactions, development of social-economic systems (Frachetti 2012; Mills et al. 2015) and diverse settlement patterns trajectories (Lawrence and Wilkinson 2015).

GIS are the main platform for the storage of archaeological data – at every level – and it embodies the maximum potential for an inter-scalar analysis, thus including several spatial domains: ***intra-site>site>near-site>off-site>inter-site***. The investigation of different spatial domains is conceived as dynamic, in which diverse patterns from local to regional scales are compared and integrated, following a cyclical critical path. The inherent meaning of "archaeological patterns" gains a higher reliability when archaeologists try to describe human behaviour relying on large data sets. The use of "Big Data" in archaeology has become more and more considered within research agendas, although, not without raising criticism among scholars who deem that big numbers will only loose the potential for detailed narratives, and others who advocate that large datasets foster the possibility of answering the really big research questions (Wesson and Cottier 2014, 2). Moreover, the interest in big-data urges big-grant funding and the development of systematic big-databases which are accessible and possibly organized within bespoke GIS platforms and ready to be used and analysed (Kristiansen 2014, 17). The demand for large databases also prompts the need for developing standardized procedures of data collection and management, in order for the information to be compared and integrated across, for instance, different surveyed regions. More recently Gaydarska (2016) pointed out that the use of large datasets, despite developing a number of accurate and advanced analytical tools, did not back up the theoretical framework for the interpretation of dry numbers and statistics.

One of the objectives of this research is to develop a critical path that combines the statistical value of the analysis of large datasets and social theory towards interpretative narratives that provide an explanation of the patterns in the data.

3.4 From numbers to people

The history of Trypillia research has seen several ways of investigating the megasites, but never really a systematic interdisciplinary research project which encompasses the study of its wider local and regional context. The TMP project gives a new perspective to the Ukrainian archaeology suggesting an alternative and innovative way of investigating the Eneolithic Trypillia culture, and its specific large settlement forms.
The amount of data collected over the last 120 years of investigation comes from all sorts of different sources so that the number of inconsistencies and inaccuracies of the data have grown and transferred over time; however, despite the uneven coverage of investigated areas, the bulk of legacy data that has been produced makes it a promising “big-dataset” for an inter-scalar analysis focussed on the study of megasites (see section 4.5 for a detailed discussion on the Trypillia legacy data).
The investigation strategy adopted in this research focussed on a number of different scales of analysis, thus using a diverse set of data for each level. The final model proposed in Chapter 6 is the result of a trans-scalar interpretation of the interplay of different domains. The advantage of this research being part of a bigger project resides in the beneficial contribution that the underpinning project’s results can provide to the thesis investigation. In this sense, the results of the project’s investigations at the sites level have been used in the doctoral research.

Three major spatial domains have been explored; the ***intra-site*** level which comprises all the data collected from the investigation of individual archaeological features at the Nebelivka (Trypillia BII) megasite; the ***site*** level which mainly includes the geomagnetic plan of the whole settlement, which was fundamental for the definition of ***household***, ***neighbourhood*** and ***quarter*** levels of analysis; and – the main focus of this research - the ***off/inter-site*** level that encompasses all the archaeological evidence located in the near and far surroundings of Nebelivka.
The trans-scalar nature of the information and domains of research made GIS the best tool to store, manage and analyse the data included in this study.
Additionally, the diverse sources of information and different accuracies could be handled in a single frame of analysis. From the single excavated potsherd, part of the individual domestic lifeway, to the household and neighbourhood domains, described by the geophysical plan as spatial units within a collective space, to the

whole megasite, its immediate surroundings, macro and regional contexts that can only be represented by surface scatters of the same potsherd that embodies a different meaning when coming from the plough-zone medium (Chapman 2010a). GIS allows for the storage of these diverse and often incomparable sources of information, but it is the user/archaeologist's task to untangle the informative potential of each piece of information and the use of it in order to answer the research questions.

The main sources of information that this research analysed were the ones coming from the ***off-site*** domain; more specifically, the immediate surroundings of megasites (micro and macro regions) and their interregional context.

The main data type analysed in this research comes from field surveys both in the form of primary data collected in the surroundings of Nebelivka, and as legacy data derived from the literature (see section 4.5).

The set of data collected in the field was aimed at the investigation of the near ***off-site*** of a megasite, in order to understand the possible traces of human activities related to the presence of the large settlement, as well as its macro-regional context. Whereas the investigation of the interregional context has been conducted on the large set of legacy data coming from the literature.

Both datasets are based on surface collection of material coming from eroded top layers of the archaeological deposits mixed within the plough-zone. Therefore, the informative potential of the material (mainly worn potsherds and burnt daub) have been used to define the presence/absence of Trypillia sites and to assess their extent. The limited informative potential of these data has been taken into account when analysed for broader regional and interregional patterns and compensated with the development of social models of human interactions that could explain such patterns. The quantitative analyses conducted on the large database of legacy data provided with the basis for interpreting the interactions between different domains and sub-groups. The household level of resolution that was reached at the megasite of Nebelivka could not be achieved for the whole spectrum of settlement data, which could only provide sites' sizes. Nevertheless, an attempt to overcome these limitations has been proposed with quantitative analyses that provided large-scale data patterns, thus suggesting broad spatial relationships between megasites and smaller settlements; as for instance the scale at which megasites become statistically big outliers compared to other Trypillia villages (see Chapter 5 for the whole set of quantitative analyses). Data patterns derived from statistical analyses contributed to the ***description*** of how the complex Trypillia settlement systems might have behaved. But it does not provide with an explanation of the meaning and the role of megasites and smaller villages within this system. Therefore, this research proposes a model, based on the data patterns suggested by the quantitative analyses, which provides with an ***explanation*** of the social meaning of these patterns within an individual-scale narrative.

The proposed 'reconciliation' between CAS and social theory will be broadly discussed in Chapter 6.
Now the attention will be turned to the concept of 'archaeological data' as the following Chapters 4 and 5 will discuss how data have been collected and analysed in this research.

3.5 Data in archaeological research

The issue of having a "good" dataset is a challenge of every archaeological project, whether it is for commercial or research purposes. Data collection and management are among the main concerns that need to be addressed within the planning phase of a research project (Campbell 2009). Archaeologists, in particular, often deal with fragmentary, inaccurate and incomplete data sets, due to a number of reasons related to the nature of the data themselves, taphonomy and degradation processes, the data collection process, the data recording methods, the data storage, the data management and publication, to mention just a few.
The concept of 'quality' of a dataset encompasses a number of aspects that the archaeologist needs to assess before attempting any sort of use and interpretation. The reliability and the accuracy of the data collection process (e.g. the sampling strategy), the accuracy in the definition of different types of archaeological features recorded from surface scatters (Gallant 1986; Bintliff 2000), the reliability of the chronological attributes of the collected material, the representativeness of the information gathered for the overall study, the location and measurements of the surveyed archaeology, the quantity and quality of collected material (diagnostic or not), the supporting mapping documentation, and the adopted reference system.

It is fundamental that this information is clear when data are published, as the way the dataset can be used depends on it; new ways of data sharing have now been established and standardized in particular for archaeological survey data with the development of bespoke databases and GIS platforms (Kansa et al. 2014; Prinz et al. 2014). Moreover, the destructive nature of the archaeological research makes the datasets populated from field activities the only source of information that will survive and therefore its reliability and accuracy assessment are fundamental. This is now a common practice among the archaeology scientific community, but it might become problematic when using legacy data or grey literature (Witcher 2008; Evans 2015), which are sometimes the principal or only sources of information, like in the case of Trypillian studies.
As previously mentioned (see section 3.2) the "status" of the data defines the array of research questions that can be posed as well as the theoretical approach to follow in order to answer them.

Before going through the vital process of the data assessment, it is useful to discuss what we mean by archaeological data and the problematic issues related to the use of archaeological legacy data.

3.5.1 Defining archaeological data

"*Field-workers are convinced that they only are revealing the realities of the past, the facts, but theorists retort that there are no facts; there are only data, chosen on the basis of theory*" (Carver 1989, 666).

The concept of 'archaeological record' has been the centre of theoretical discussions for a long time, but archaeologists have failed to reach consensus. Scholars have argued that the archaeological record has nothing to do with the material culture that we find on the ground, but it refers to the actual living scenery behind the mere objects and that the material remains *"...merely provide a frame to support a pattern of more vital tissue.*" (Childe 1956, 38). Others have argued that it is possible to recover the structure of the total cultural system behind the archaeological record, conceived as the fossilized remains of past activities, although it is mostly not possible to reconstruct what kind of activities were performed from the material remains (Binford 1962, 219).
Notwithstanding, archaeologists have always referred to the 'archaeological record' as a number of different things, thus making the term quite 'catch-all'. The term has been used in a rather confusing way, often leading to semantic debates, rather than helping advance scientific communication.
Patrik (1985) tried to summarize all the different conceptions into five categories, as follows: 1) past objects and events; 2) material remains; 3) material deposits; 4) archaeological samples; and 5) archaeological documentation (Patrik 1985, 30). A more recent (re)-definition of the notion is summarised in three major categories: 1) artefacts and material culture; 2) residues and formation theory; and 3) sources and fieldwork, where the intangible domain seems missing in favour of a broader but thorough categorization of different levels of materiality (Lucas 2012).
If we try to look beyond the various labels and the different meanings of each term, we can distinguish two major components of what we can call archaeological data as such. The first consists of all the physical material that lies either under or above ground, which is of interest for the archaeologist who wants to study past human activities and behaviours; this can be identified with Patrik's ***physical model*** as a fossil record produced by a sequence of human actions that unconsciously left physical traces on the ground (Patrik 1985, 33). The second category refers to fieldwork activities, such as excavations and surveys, and field recording procedures that produces what Lucas describes as ***archives*** (Lucas 2001), which

will then be used in the overall interpretation phase of the research. The combination of excavation, survey and recording processes builds up what can be defined as "archaeological data" constituted by ***read-once*** components, such as soil marks or negative contexts that will only remain in texts or photos, and ***re-readable*** objects collected and preserved for future analysis (e.g. finds) (Carver 1989, 669). The 'creation' of archaeological datasets depends on a number of factors that make it a one-off and rather subjective exercise which becomes vital if we consider that records or archives – not the actual remains themselves – constitute the principal basis of the interpretation and the only information left (Lucas 2001, 44).

It has been already widely discussed and established that the practice of data collection and 'creation' is biased by the theoretical and interpretative approach adopted during the process "***Interpretation occurs at the trowel's edge***." (Hodder 1999, 83). Moreover, the archaeological facts or data can change in the light of what the archaeologist deems an important and significant attribute of a specific object (Clarke 1968, 15).

Although, the archaeological remains – both buried and upstanding – are the same for everyone to be investigated and recorded, there are no un-biased procedures that would allow for an objective and non theory-laden data collection. The way archaeologists even decide where and how to put a trench over an archaeological deposit, has to start from an initial understanding and interpretation of the site (Hodder 1999, 82). Therefore, despite the field-workers and academic community's efforts to find a standardized protocol to record the archaeology during fieldwork practises, the compilation of the dataset of any sort still remains strongly subjective. In a post-excavation/survey phase though, field data are reinterpreted in a wider context of the project research questions. Nevertheless, there are different aspects of the data collection process that can be aided by technological and theoretical advances, so that a minimum set of requirements has to be met in order for a dataset to be re-read and interpreted by someone who has not been involved in the excavation or field survey. Since the records and site documentations will be the only evidence left from the field activity, and given the strongly subjective nature of it, it is important for the scientific community that a minimum standard of field recording are set and met, in order to define the quality of the data (see above). In this way there is still a chance of having a sort of replicability of the secondary interpretation, which is one of the weak aspects of the discipline of archaeology that is now increasingly considered as social "science". The topic of replicability in archaeology has been discussed for decades (e.g. Fish 1978), especially with regards to classification of objects, which is a rather subjective exercise. More recently the issue has been addressed and tested for the more 'scientific' side of the discipline (Atici et al. 2013; Frahm 2012), showing that at least the discussion on this issue is still ongoing. Nonetheless, the problem of non-replicability of archaeological investigations seems now out of date and is not considered in a recent general discussion regarding the status of archaeology as ***social science*** (Smith et al. 2012).

The fact that field surveying activity will never involve the collection of all the surface material and that this is “freshly” yielded by regular ploughing events, makes it, arguably, the only kind of archaeological invasive investigation that leaves a certain level of replicability (at least in the Mediterranean, Near East, Ukrainian and any other ploughland). Although this is probably not completely true, as the intense agriculture will eventually erode and destroy the archaeological deposits (Cherry 2003, 157), field survey-derived legacy data still give us the opportunity to at least double-check their reliability by testing new methodologies on the same (rather not) archaeological remains, thus building different datasets, which can be compared (see Banning et al. 2016 for Quality Assurance approaches to archaeological surveys).

3.5.2 Legacy archaeological survey data

The importance of legacy data in archaeology today is invaluable as they represent, in some cases, the only source of information for large-scale and regional studies. Primary data are not enough to analyse trans-regional patterns that would help in understanding local settlement dynamics as well. Field survey data, despite their coarse-grain spatial and chronological resolution, can still provide fundamental insights for the study of social phenomena like the development of mega-sites in the Late Neolithic Ukraine.

Generally legacy data are considered to be less accurate and reliable than primary data, for two main reasons. Firstly, they often lack a complete set of metadata documentation where the methodology and the procedures adopted are clearly explained, and therefore, their reliability can’t be assessed (Chapman et al. 2010b: section 2.1.2 and 2.1.3). Secondly, the methodologies are often sub-optimal compared to more recent years when the theoretical debates developed new methodological approaches to the field survey (Witcher 2008). New technological and theoretical advances allow for a more accurate definition of site, site size, site location, site and off-site scatters, site density, to mention a few. Different techniques and theories lead to the composition of different datasets, even though the starting archaeological remains is the same. The great potential for field survey to be a replicable exercise, thus giving the possibility of assessing its objectivity, shows how subjective the discipline is; Petrie’s statement “***When recording archaeology in the field, the first difficulty is what to record***.” (Petrie 1904, 49) embodies the main issue regarding the composition of a set of data. Moreover, further contextual conditions (such as ground visibility, land cover, weathering and taphonomic processes) affect

each survey and its results; even if this is conducted on the same area using the same methodology.
Given the overall inconsistency and irregularity of field survey activities and the consequent variability and discrepancy in the datasets yielded, the use of legacy survey data becomes even more complicated and problematic.

A source-criticism approach is therefore needed when the analysis and interpretation is mostly reliant on legacy data. The case of Trypillia megasites, addressed in this research, will provide an example of how to deal with a massive amount of poorly reliable information and how to make the best use of them.

3.6 Conclusions

In summary, this Chapter presented the background behind the theoretical framework embraced by this research with particular stress on the importance that the data quality plays in the development of the methodological approach. The proposed reconciliation between complex systems theory, quantitative analysis and social theory represents a nuanced perspective for the study of Trypillia megasites, as well as for settlement archaeology in general.
The next Chapter will discuss the various contributions of remote sensing and primary field survey to the present research.

Chapter 4: Remote Sensing, Field Survey and Database

4.1 Introduction

In this Chapter the main contributions of remote sensing, field survey and GIS to Trypillia studies will be elucidated. In the first part, a number of available satellite imagery ranging from 1960s CORONA images to the more recent WorldView-2 datasets will be evaluated for their potential value in researching megasites, as well as smaller Trypillia (and other period) features. Results of the photo-interpretation will be discussed.

The second part will deal with the results of the field survey conducted in the hinterland of Nebelivka, in both the micro (5 km radius) and macro (25 km radius) regional study areas. Different sampling techniques and the main results will be discussed.

The third part will examine how remote sensing and field survey data have been combined in order to assess the reliability of legacy data. The process of data assessment and 'data cleaning' will be discussed.

4.2 Remote Sensing

Since the 1960s, Trypillia settlements have been mapped from aerial photographs, starting with the military topographer Shishkin's flights in 1964. Shishkin later surveyed several sites, including the major mega-sites of Maidanetske, Taljanki and Dobrodovy (Shishkin 1973; Shishkin 1985).

Observation from an "elevated" point of view has always been useful for archaeologists to comprehend the spatial context of archaeological sites in their entirety, but also to detect and map features as part of the archaeological record. Each feature is the result of past human activities that built up a complex palimpsest of traces that needs to be untangled. The "remote" perspective allows visualizing and analysing a wide territory at different scales and helps with contextualization, and thus interpretation, of the objects mapped. Archaeology has been using remote sensing for a long time now, and scholars have more aware of the potential opportunities and limitations of such data. Therefore, considering the variety of data sources, cost and area of investigation, an initial assessment of the datasets is necessary. The visibility of archaeological sites and features from satellite images varies according to the shape and size of the site, the nature of the site, the location of the site, the contrast between the land cover of the surroundings and of the site itself, the state of preservation of the site, the spatial and spectral resolution of the image, the time of acquisition of the image and the different satellite sensors (Sabins 2007). All these variables have even more impact on the recognition of archaeological remains that are completely buried under the ground surface, as is the case for the Trypillia sites. Hence, two further factors have to be taken into consideration in order to understand what we can see from the imagery, namely the depth of the archaeological horizon and the land cover of the area at the time of the data acquisition.

The reason why we can "see archaeological remains" on satellite images is that the presence of something under the ground surface can affect the content of soil moisture and the growth of crops. This can happen thanks to a series of post-depositional processes such as deep ploughing which erodes the archaeological remains and brings fragments to the surface. Therefore, if the archaeological deposit lies within the plough-zone there is a high possibility that this both affects the moisture content of the higher horizon of the soil and restrains the growth crop. Nonetheless, the phenomena do not always occur at the same time, therefore the land cover determines the visibility of buried archaeological features - as in the case of the chernozem soil, which characterizes the investigated area in Ukraine.

Given all the variables mentioned, it is important to consider a variety of datasets and assess the potential and limitations of each in the specific environment under investigation.

A number of different types of imagery have been used and tested with diverse spatial and spectral resolutions, time of acquisition, sensor, coverage and cost.

4.2.1 Shuttle Radar Topography Mission (S.R.T.M.)

The Shuttle Radar Topography Mission (SRTM) is the most commonly available dataset for topographic data and has a worldwide coverage. It used a radar apparatus mounted on the Space Shuttle Endeavour and collected data for 11 days on February 2000 at a nearly global scale (56° S to 60° N). The data released are freely available for the United States of America at 30 m horizontal resolution and for the rest of the globe at 90 m horizontal resolution. Since 2015 new sets of data have been released and now a worldwide coverage of 30 m resolution is available for free. The approximate height error is around 8 m for Eurasia (Rodriguez et al. 2006). The data have been used to study the geomorphological characteristics of the study area and to analyse site locations in comparison with the hydrological network[7]. Moreover, the SRTM worked as a basemap for the automatic extraction of the river network and was utilised to calculate slope and elevation values that were integrated in the logistic regression test (see Chapter 5).

4.2.2 Landsat

In terms of optical data, Landsat represented the basic geo-referenced image source for the GIS platform as it has a worldwide coverage and it is freely available to download from the USGS website[8]. The Landsat mission has been running since 1972 when the first satellite (Landsat 1) was launched in orbit. Since then 8 satellites have been sent into orbit (with the exception of Landsat 6 which failed) at least twice each decade until now. The first three satellites, operational from 1972 until 1983, used a Multi Spectral Scanner (MSS) sensor, thus producing multi-band imagery covering the spectrum of the visible (red, green and blue) and two near infrared (NIR) channels. The spatial resolution was 80 m. Landsat 4 and 5, launched in 1982 and 1984 respectively, were carrying Thematic Mapper (TM) sensors which delivered 7 bands of imagery; including the visible spectrum, two near infrared (NIR), short wavelength infrared (SWIR) and thermal infrared (TIR). The spatial resolution was of 30 m and 120 m for the thermal infrared. Landsat 7, launched in 1999 and still operational, uses an Enhanced Thematic Mapper Plus (ETM+) sensor and includes the same bands as the previous satellites, but with an enhanced spatial resolution of 30 m also for the thermal infrared, and a panchromatic band at 15 m resolution. Finally, Landsat 8 launched in 2013 uses an Operational Land Imager (OLI) sensor which includes 11 bands; along with the traditional channels it has a coastal/aerosol band, and extra SWIR band, a cirrus band and an extra thermal band. The extra value of this product is the pixel depth of 12 bit which makes the atmospheric noise easier to exclude and increase the levels of greys from 256 to a potential of 4096.

Due to its low spatial resolution, Landsat cannot be used for archaeological site detection and mapping, as the pixel size is too big to describe an average archaeological buried feature; only in some cases, like the tell sites in the Near East (Adams 1981, 33) or other massive up-standing features, can Landsat be used for identifying archaeological remains, although it would be complicated to estimate the nature and the size of the site.

A more functional application of Landsat imagery is the mapping of different land uses, with the help of different band combinations and vegetation indexes (e.g. NDVI) useful in identifying different land covers as well. In this research it has only

[7] http://www2.jpl.nasa.gov/srtm/index.html (accessed 2nd June 2015)
[8] http://landsat.usgs.gov/ (accessed 2nd June 2015)

been used as a reference map for georeferencing other satellite imagery (e.g. CORONA), and for a general overview of land uses.

4.2.3 High resolution imagery

In order to detect and map buried archaeological remains such as Trypillia sites, a set of high resolution imagery is needed and a potential assessment has to be done before deciding which kind of imagery to purchase; unfortunately, the cost of data always dictates the research agenda.

Only a high spatial resolution allows for the detection of archaeological features and the so called "anomalies" indicating the presence of something underground can be of various nature; the ways archaeological features (or other phenomena) manifest themselves on aerial images can be ***crop***marks (when there is a differential growth in the crops), ***soil***marks (when there is a differential moisture content in the soil), ***shadow***marks (when the object topographical expression produces a shade), and many others (Wiseman and El-Baz 2007; Lillesand et al. 2008; 2014).

Two main sets of imagery have been tested and only one of them turned out to be useful for the identification of archaeological features in the study area.

4.2.3.1 CORONA

The CORONA was the first American satellite programme, operational from 1959 until 1972, devoted to a photographic surveillance of the Soviet Union, People's Republic of China and other key areas.

The programme was officially classified until 1992[9] when the images were considered obsolete for military purposes; hence they started to be released to the public. The products are black and white panchromatic frames covering 200 km length by 15 km width with a spatial resolution of 2-4 m. This meant an enormous amount of historical aerial images which allowed archaeologists to investigate vast territories in a pre-urbanization and pre-agricultural scenarios, where the visibility of archaeological sites and their contextual landscapes are now lost. The great potential of such imagery in arid and semi-arid areas has been established over 15

[9] http://upload.wikimedia.org/wikipedia/commons/transcoded/2/2a/A_Point_in_Time_-_The_CORONA_Story_-_NRO_document_about_Corona_project.ogv/A_Point_in_Time_-_The_CORONA_Story_-_NRO_document_about_Corona_project.ogv.360p.webm (accessed 2nd June 2015)

years of research; CORONA images have been used with particular success in exploring the archaeology of the Near East, where the remains of tells, flat sites and route ways are clearly visible on the images (Ur 2003; Ur 2005; Hritz 2014).

The three main advantages of CORONA are, 1) the relatively low cost, for a vast coverage, of each frame (200 km x 15 km); 2) the fact that they show an historical scene where archaeology is still preserved before urban or agricultural encroachment; and 3) the availability of time-series of images which provides the possibility of seeing features that might be masked in different years. This makes them, potentially, the favourite satellite dataset for archaeologists.

Nevertheless, they are not always the best dataset for archaeological reconnaissance and its potential has to be evaluated for the specific research territory case by case.

A set of panchromatic CORONA full frame images acquired in 1967 with a spatial resolution of 2 m was purchased for the entire study area in order to get a suitable quality for archaeological applications.

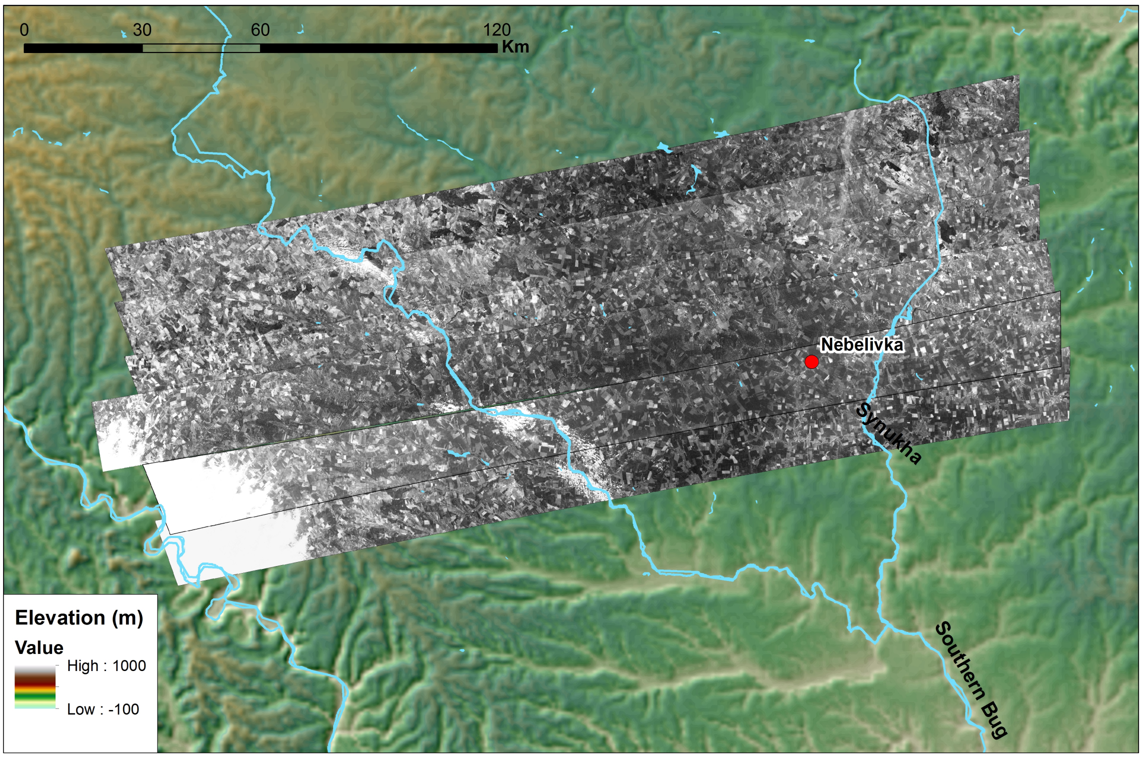


Fig. 4.1. Coverage of CORONA imagery for the study area.

The assessment of the imagery potential for archaeological reconnaissance consisted of three phases, according to what has to be evaluated.

In order to assess the visibility of archaeological features on CORONA imagery, for the mapping of archaeological features in the Ukrainian steppe, two tests have been carried out; 1) a predictive photo interpretation in ***terra incognita*** of the area of interest; and 2) a post-dictive comparison of known sites clearly discernible on other high resolution datasets, such as WorldView-2 (for the micro-region) and Google Earth sets of imagery (for the regional domain).

A first glance at the images showed an obvious class of round anomalies that made the archaeological mind immediately think about some sort of round-shaped, Trypillia-like, settlements. But after an accurate examination, it seems that those were possible traces of air bubbles produced by the contact of the film with the glass of the scanner, during the digitalization process. Other smaller features that resemble burial mounds (Kurgans) have been detected and initially interpreted as archaeological features; then an accurate inspection of the image revealed their real nature of scanning artefacts. The scanning of old film images always produces errors and distortions on the final output (Gheyle et al. 2011).

The knowledge of the archaeology in the territory assisted in the second post-dictive assessment; after checking the visibility of known Trypillia mega-sites on the CORONA images, it turned out that only one settlement (Nebelivka), out of eight, manifests itself on the image as a slight anomaly that can be interpreted as a potential archaeological site.

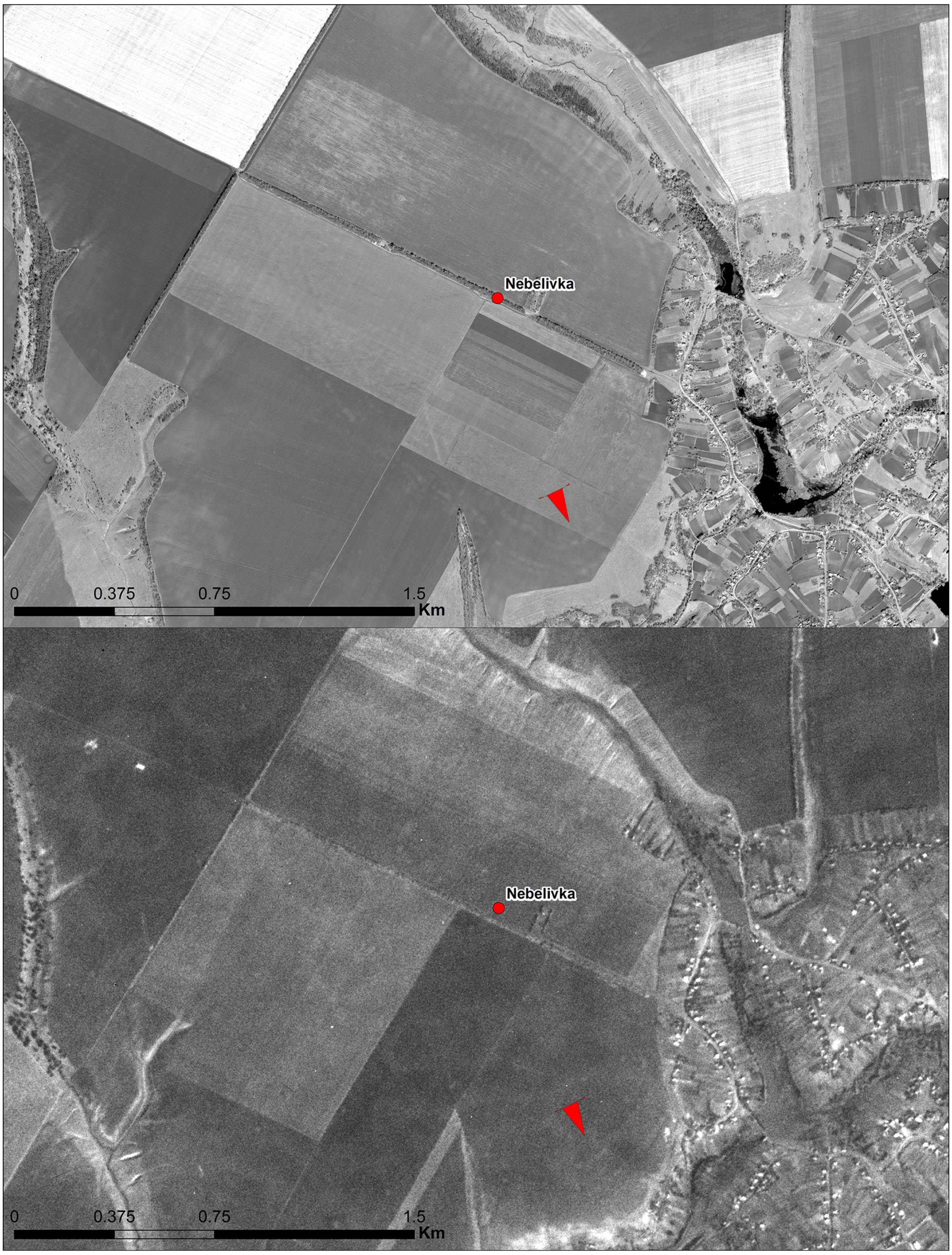


Fig. 4.2. Comparison of the visibility of Nebelivka on the 2008 WorldView-2 and on the 1967 CORONA satellite imagery.

This result is due to two main reasons related to the type of data; firstly the spatial resolution of 2 m is not high enough to undertake mapping of such subtle features as flat buried Trypillia sites.

The reason why we can see these sub-surface archaeological remains on high resolution satellite imagery is that they can produce anomalies in the soil moisture and retain crop growth, not because they are up standing monuments producing shadows that can reveal their presence and shape. Therefore, the spectral resolution plays an important role in the feature detection as it can help by enhancing the way soil moisture and crop growth can be seen on the imagery. A number of image enhancing procedures like Principal Components Analysis, Decorrelation stretch, or Vegetation indexes like NDVI or Ratio, can highly stress the anomalies and make them more visible on the imagery, but cannot be performed on CORONA due to their limited spectral resolution to one panchromatic band. Hence, this is the second reason why CORONA images are not the best for recovering archaeological sites in Ukraine.

A further evaluation has been carried out by comparing CORONA data with higher resolution imagery like WorldView-2 and Orbview-3 (Fig 4.2). Assuming that the more times a feature is visible on different datasets the higher the degree of certainty that the feature corresponds to “something” buried, we can evaluate the reliability of the image for that class of objects. The result shows how very few features were recognizable on CORONA as archaeology, and even monuments like burial mounds (sometimes 3 m in height) were not easily detectable. The two red arrows in Fig. 4.2 show how the features indicating part of the house circuits on the southeast corner of Nebelivka are visible on the WorldView-2 (top) and CORONA (bottom) images. Unfortunately, this is the only case in which CORONA imagery shows an archaeological feature in the study area. The spectrum of anomalies mapped on other datasets, from the very subtle to the more evident, is not even comparable with the CORONA imagery, thus meaning that these types of images are definitely not suitable for archaeological application in this part of the world.

Even the fact that these are historical images, taken 50 years ago, doesn't play such an important role as in the Near East (Ur 2003) where they show a pre-urbanization scenario. The rural areas investigated for this research are still unaffected from any sort of urbanization process.

Nonetheless, the historical value can be appreciated when mapping past hydrological networks which appear to have been active at the time when Nebelivka was occupied; it’s quite clear from the geophysics data that the lay-out of the dwellings respects limits of a palaeochannel which was allegedly active at the time of site occupation.

A final, possible, limitation of CORONA imagery could be related to the erosion of the topsoil due to deep ploughing activity carried out during the time elapsed since the data acquisition, so that the archaeological remains are closer to the current ground surface and therefore more easily visible on recently acquired images.

In conclusion, the contribution to the study made by CORONA imagery is, unfortunately, very limited, and therefore the project necessary purchased higher resolution and more expensive datasets, such as WorldView-2, for targeted areas.

4.2.3.2 WorldView-2 and OrbView-3 imagery

The CORONA assessment for recovering archaeological remains in the territory under investigation in Ukraine led the project to purchase higher resolution imagery. The ratio of cost to coverage always dictates the research strategy. Therefore, a first sample set of images was acquired for the 5-km hinterland around Nebelivka. WorldView-2 was judged the best dataset on the market, both in terms of its spatial and spectral resolution, for archaeological application, and specifically targeted to overcome the above-mentioned visibility limitations (Fig. 4.3).

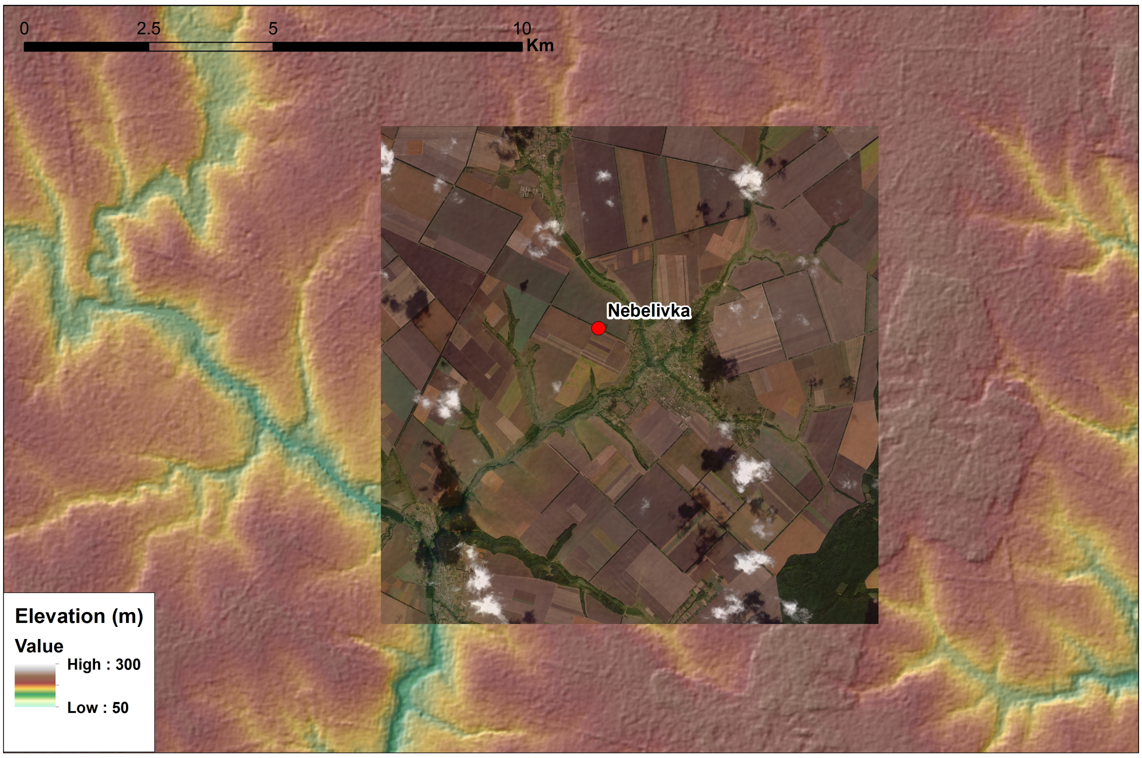


Fig. 4.3. Coverage of the acquired WorldView-2 satellite images (8-bands multispectral 1.85 m and panchromatic 0.46 m) for the Nebelivka micro-region (5 km radius).

WorldView-2 is a commercial Earth observation satellite owned by the company DigitalGlobe[10] which provides panchromatic imagery of 0.46 m resolution and 8-band multispectral imagery of 1.85 m resolution. It was launched in October 2009 and it takes a photograph of any spot on the Earth almost every day.

The high-resolution images certainly represent a better data source for archaeological applications, nevertheless a visibility assessment was necessary to establish their potential for mapping the area of interest. As mentioned above, having a multi-spectral dataset allows the performance of a number of image processing and feature enhancements, thus stressing the vegetation growth and soil moisture content as key factors in detecting buried archaeological remains. At first the focus was on the near hinterland (5 km radius) of Nebelivka for which the project purchased a mosaic of multi-spectral and panchromatic images (0.034% cloud cover). After a pansharpening[11] process a higher resolution of 0.46 m has been achieved for the multi-spectral imagery as well, thus producing the best satellite imagery available commercially, in terms of both spatial and spectral resolution.

The choice of taking as unit of investigation an area of 25 km radius around Nebelivka, has been dictated mainly by costing reasons, as it would have been too expensive to purchase WorldView-2 images for a wider territory. Therefore, a full coverage of panchromatic (0.46 m resolution - 0.001% cloud cover) imagery has been purchased for the Nebelivka micro-region (Fig. 4.4)[12].

[10] https://www.digitalglobe.com/about-us/content-collection (accessed 11th June 2015)

[11] Pansharpening is the process of combining a low resolution panchromatic image with a high resolution multi-spectral image in order to obtain a high resolution multi-spectral image. In most remote sensing software packages such as ERDAS Imagine (used in this study) this procedure is easy, automated, time effective and accurate.

[12] The data purchased were collected at different dates: 30th March 2014, 27th April 2012, 14th April 2008, and 6th September 2011.

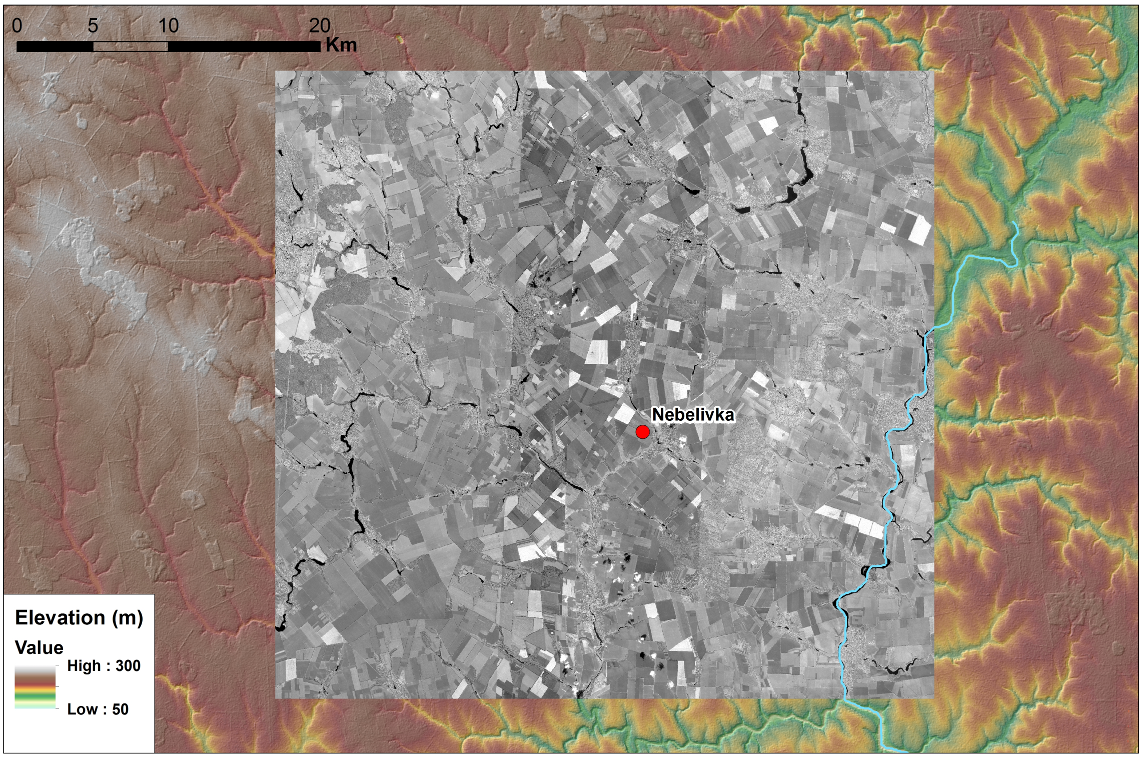


Fig. 4.4. Coverage of the acquired WorldView-2 panchromatic (0.46 m) satellite image for the Nebelivka macro-region (25 km radius).

The dataset covers a territory where a Trypillia presence is known in the western part, whereas the southeastern area is generally archaeologically unknown. This presented the opportunity to test the potential of the remote sensing data both on an archaeologically known area and in ***terra incognita***.

OrbView-3 was an Earth observation commercial satellite owned by GeoEye until the company DigitalGlobe purchased it in 2013. It was operational from 2003 until 2007 when GeoEye announced it to be out of service. OrbView-3 produced 1m resolution panchromatic and 4 m 4-bands multi-spectral imagery, although only the panchromatic products are freely available from the USGS (United States Geological Survey) website[13]. The use of OrbView-3 was to compensate for the lack of WorldView-2 coverage.

For a smaller area in the northeastern part of the micro-region, two OrbView-3 images were also downloaded for free, even though the overall coverage of this imagery is very patchy.

[13] http://earthexplorer.usgs.gov/ (accessed 11th June 2015)

4.3 Archaeological mapping from satellite imagery: geodatabase and feature extraction

Since 1899 people have taken pictures from the air to have a different perspective on the archaeological landscape; sites like Pompeii and Stonehenge (1906) were the first to be looked at from an elevated point of view. This brought a unique overall view of these imposing sites and provided new insights on the contextual surrounding landscape. The history of aerial archaeology has seen a constant development since the 1920s, when the first flights were specifically devoted to archaeological reconnaissance of known sites, excavation trenches and to find new sites. Since then, technological advances have led to a variety of remote sensing data sets spanning from passive sensors, like aerial photos and satellite imagery, to active sensors such as LIDAR and the whole spectrum of ground based geophysical techniques (Rączkowski 2015). The whole spectrum of data available nowadays is incredibly varied but coverage is uneven across the globe. Therefore, often the choice to use one type of data over another is due to the lack of available sources. As for this study, the main utilised data sources were satellite imagery, because of their general worldwide availability and for the favourable ratio between quality and cost.

The technology of data acquisition is developing quickly along with image mapping procedures, which are moving towards a full integration and cross-validation of imagery and remotely sensed features.

As more and various data became available, the necessity of handling large quantities of information has led to the development of bespoke databases able to store such large amounts of big-data and to combine those from different sources. Geographical Information Systems are the best platforms for the storage and management of not only the data sources, but also of the information derived from data analysis and interpretation. The data model embedded into the ESRI ArcInfo GIS package (geodatabase) enables the management of different types of imagery and spatial data coming from remote sensing interpretation combined with field data, thus assessing the potential of the imagery for archaeological applications.

4.3.1 Mapping satellite imagery: the geodatabase

The feature mapping process has been developing since the beginning of photo-interpretation analysis, and new ways of storing mapped data have been theorized and applied. As mentioned above, the best toolkit to manage spatial data are GIS systems and their embedded geodatabases which develop from a bespoke data model for the topological nature of the information. The satellite mapping, in this project, involved different datasets, therefore it is fundamental to establish a system to optimize features-recording, thus enabling a more punctual comparison between types of imagery.

Accordingly, a geodatabase customized for remote sensing analysis has been structured so that every useful piece of information, regarding the features, can be stored and represented geometrically as a point, a polyline or a polygon (see Appendix B). Each object is represented as a **polyline**, because what is being mapped is conceived as the interface (therefore a line) between the anomaly produced by the object and the image background.

The data recorded describe each mapped object with various attributes; **region** locates the county (oblast) where the object is situated, **location** provides information about the municipality where the feature has been mapped, **dataset** indicates which dataset has been used to map the feature, **feature shape** describes the shape of the feature (linear, curvilinear, polyline, circular, quadrangular, polygonal, sub-circular), **spectral signature** describes the appearance of the feature in the image as dark or light (this can give some insights on the nature of the object, namely whether the feature is positive, like a wall, or negative, like a ditch), **type of anomaly** defines the reason why we can see the feature (whether it manifests as cropmark, shadowmark, soilmark, weedmark, dumpmark) and that also hints at the nature of the feature, **origin** defines whether the object has a natural or anthropic origin, **interpretation** tries to explain what we are seeing in the image, based on all the previous information and on the context, **certainty** states the level of certainty of the interpretation and finally **ground truth** simply defines whether a feature has been visited on the ground or not.

All the values of each attribute are predetermined - on the basis of a general knowledge of what kind of information can be extracted from an image - and organized in different lists of close vocabularies, termed *Domains*, thus preventing redundancies in the database.

The non-invasive nature of remote sensing makes it a repeatable "experiment"/analysis; moreover, this systematic data recording contextualizes the information gathered into a framework more suitable for comparisons and cross-evaluations. This approach is aligned with a comparative and experimental perspective where punctual comparisons of "experiment" results enhance the value of the analysis interpretation.

4.3.2 Mapping the archaeology: image processing

The visibility of buried objects on the imagery depends on many factors, some related to the features and some related to the imagery. Factors regarding the archaeological objects being mapped are; shape and size of the feature, nature of the feature, location of the feature, contrast between the land use of the surroundings and of the feature itself, state of preservation of the feature. Whereas factors that affect the visibility and interpretability of buried features, related to the datasets we are looking at, are the spatial and spectral resolution of the image, the time of acquisition of the image (meaning both time of the day or season) and different satellite sensors. It is clear that nothing can be done for the first set of variables, therefore, the best practice would be to have a series of different imagery which would help to overcome some of the problems related to the second set of variables. Unfortunately, financial constraints often prevent the acquisition of the spectrum of datasets necessary to do that, hence we have to extract all the information possible from the available set of imagery.

Since the beginning of remote sensing, a number of standardized image processing procedures have been developed in order to stress the spectral properties of features, thus enhancing their visibility on the imagery (Colwell et al. 1983; Sabins 1987; Sabins 2007; Aqdus et al. 2012; Lillesand et al. 2014).

Satellite imagery has well-established procedures to enhance the mapping potentials depending on the type anomaly or feature of interest (Hadjimitsis et al. 2013). Moreover, the combination of different datasets - multi-temporal data fusion (Zhang 2010) - can help in increasing the image classification accuracy and increasing the certainty of a feature being archaeology on the basic principle that the more an anomaly is visible in several datasets, the higher is the probability that the underlying feature is of an archaeological significance. The self-validation of remote sensed data has been tested in the Near East, where the high potential of CORONA imagery for archaeological detection has been combined with the availability of multi-temporal ASTER data (Menze and Ur 2014).

Overall, the more datasets that are used and combined together, the less variance in feature visibility.

However, the majority of research projects relies on fewer, if not single, satellite datasets, therefore, the focus is on the enhancement of the different types of "marks" through which the buried archaeological remains manifest themselves.

Due to the ephemeral nature of the traces left by Trypillia sites, this study has chosen to use WorldView-2 imagery which provides the spectral resolution necessary to perform a number of feature enhancement procedures at a high spatial resolution. The analysis of the first set of 8-bands imagery, purchased for the near hinterland of Nebelivka (5 km), helped in assessing, firstly, what kind of anomalies were showing up on the images. An intensive photo-interpretation of the area, based only on the natural colour display, produced about 300 entries in the geodatabase.

The sheer number of features mapped in 100 sq km showed the potential of WorldView-2 for detecting buried and semi-buried objects. Moreover, the types of anomaly suggest that the enhancement of both soil moisture and vegetation growth visibility might contribute to the recovery of even more features.

Standard procedures like Vegetation Indices (VIs) are combinations of the surface reflectance at different wavelengths and they are designed to highlight the properties of different types of vegetation or different vegetation growth levels (Goward et al. 1991). Green vegetation has a high Near Infrared (NIR) reflectance and can be easily distinguished from dry vegetation and soil (Verhoeven 2012, 137). Therefore, the ratio between the red and the infrared wavelength expressed in the Normalized Difference Vegetation Index (NDVI) can stress the state of vigour of the crop growth, thus revealing even more subtle anomalies manifesting as cropmarks.

Vegetation indices have a number of applications at different scales and spatial resolutions. They can be used to analyse general vegetation health status (Viña et al. 2011), or to enhance the visibility of archaeological features (Lasaponara and Masini 2006; Bennett et al. 2012) or, combining the two, to monitor the state of preservation of archaeological remains in vegetated areas (Kincey et al. 2014). Furthermore, other VIs highlight vegetation growth by stressing how the phenological cycle is affected by the presence of archaeological remains underground (Agapiou and Hadjimitsis 2011; Agapiou et al. 2012).

Other image processing techniques, which rely on different spectral properties of the image, can enhance the visibility of archaeological features. Usually a combination of more than one technique can emphasize the magnitude of single anomalies (Noviello et al. 2013). Remote sensing can detect a number of soil properties such as mineralogy, texture, soil iron content, soil organic carbon, soil salinity, carbonate content and soil moisture (Mulder et al. 2011). Moisture content is commonly the main soil property that is used to detect sub-surface archaeological features. The NIR band is sensitive to water presence as water totally absorbs the infrared electromagnetic wavelength; therefore, features like palaeochannels or irrigation systems, which retain humidity and moisture, are particularly visible in the NIR band (Verhoeven 2012).

The strategy of choosing the right image processing technique to apply to the imagery usually follows trial and error, rather than a deductive process, as the ways in which sub-surface features manifest are various. However, the two most common approaches are related to either enhancing the reflectance properties of the vegetation or the soil in order to stress the visibility of the anomalies, or to enhance the colour contrast to stress hues and tonality differences.

There are a number of procedures to improve the visual capability of interpreting an image by "artificially" increasing the distinction between the feature/anomaly and the background scene. The spectrum of techniques is potentially limitless; however, it is possible to categorize them as spectral contrast manipulation, spatial feature manipulation and multi-image manipulation. The more common contrast manipulation related technique, used for archaeological applications, regards the stretching of pixel values over a range of 256 grey levels (maximum number of levels represented in an 8-bit encoding) in order to stress the contrast between the feature of interest and the background. Other sorts of image classification such as level slicing, where pixel values are grouped in different ranges-slices, help to better define the feature outline compared to the background "noise" (Lillesand et al. 2008, 500-508).

Spatial feature manipulation techniques, instead, deal with image data spatial frequencies, either emphasizing or de-emphasizing frequencies of different features of interest. Low pass filters stress low frequencies and they are used to clear the background noise which can prevent the detection of archaeological anomalies, whereas high pass filters emphasize high frequencies, thus locally highlighting the visibility of high frequency features (usually much brighter in a grey scale image). Both filters operate at a local level and can use different kernel masks to define the best pixel neighbourhood to highlight a specific object. Moreover, other procedures like edge detection (which include Gaussian, Laplacian and other filters) and fast Fourier transform help in defining more clearly linear-shaped features outline in order to better classify them against the rest of the image (Sabins 2007, 266-274). Finally, multi-image spectral processing operates with multi-bands datasets and combines the pixel values at different wavelengths, thus enhancing the visibility of a single feature in each wavelength. ***Principal Component Analysis*** (PCA), applied to a multi-spectral image, retrieves the unique information from each band and compresses the data into new, fewer, bands. This can enhance the visibility of the features of interest[14] or help with image classification and segmentation (Lillesand, Kiefer, and Chipman 2008, 527). Likewise, ***decorrelation stretching*** stresses the information variability between different bands in a multi-spectral image, namely highlighting the difference in intensity, hue and saturation among different wavelengths; this technique is used mostly to enhance the visibility of features which appear quite similar in each band (Lillesand, Kiefer, and Chipman 2008, 545).

The array of image processing and feature enhancement methods includes potentially limitless possibilities, although the benefits are negligible for archaeological applications. Moreover, there is not a perfect image enhancement procedure, as each technique stresses either the different properties of the anomaly itself or the way it manifests on the image; therefore, a trial and error approach is still the best in most situations.

4.3.3 Mapping archaeology in the Ukraine.

The knowledge of what types of anomaly we are looking at facilitates the choice of which procedure to apply to the image in order to enhance the visibility of the archaeology. The intensive analysis of the multi-spectral WorldView-2 image produced over 300 features, mapped using a natural colour display (WorldView-2 multispectral acquired on 17 September 2011) (Fig. 4.5).

[14] It has been used a lot and became a standard procure with Lidar data, see (Devereux et al. 2008).

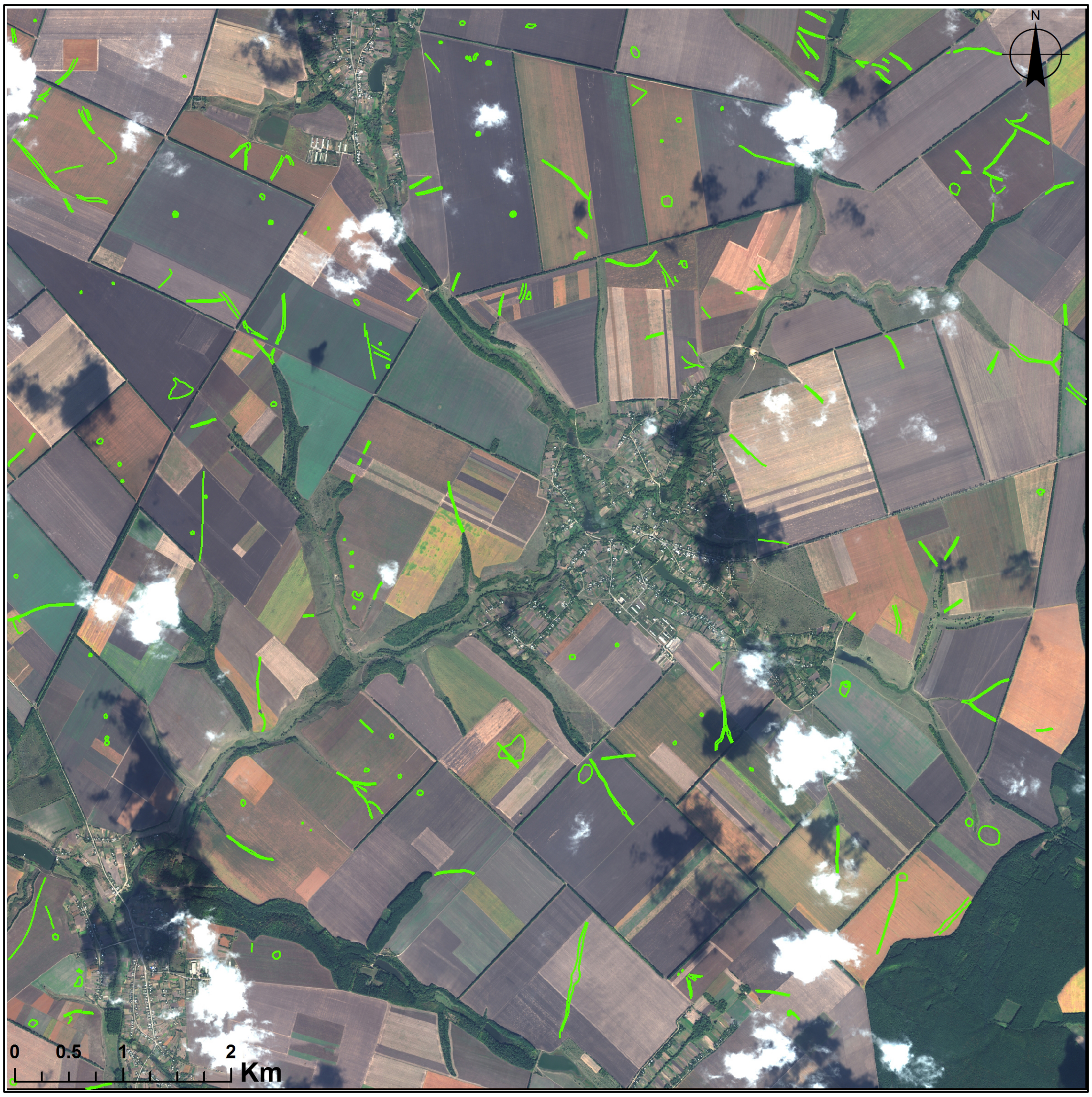


Fig. 4.5. Distribution of anomalies mapped on the WorldView-2 satellite image, Nebelivka micro-region.

The results showed how, overall, 51% of the features manifest as cropmarks - namely that the presence of buried features restrained the crop growth - and 43% as soilmarks - namely that the presence of features affects soil moisture. Only 21% of the features have been attributed to an anthropogenic origin, whereas the majority of the rest show an intricate palaeo-hydrological network (Fig. 4.6). Considering the sole features relating to potential archaeological sites (which include the Nebelivka mega-site, burial mounds and other potential smaller sites), 76% manifest as soilmarks (Fig. 4.7). The rotating agriculture regime allows us to appreciate the different visibility of the same feature on two different land uses;[15] therefore, it was possible to attest that in cultivated fields the archaeological anomalies are pretty much invisible.

[15] This is possible whenever we have two images, taken at different times and covering the same area.

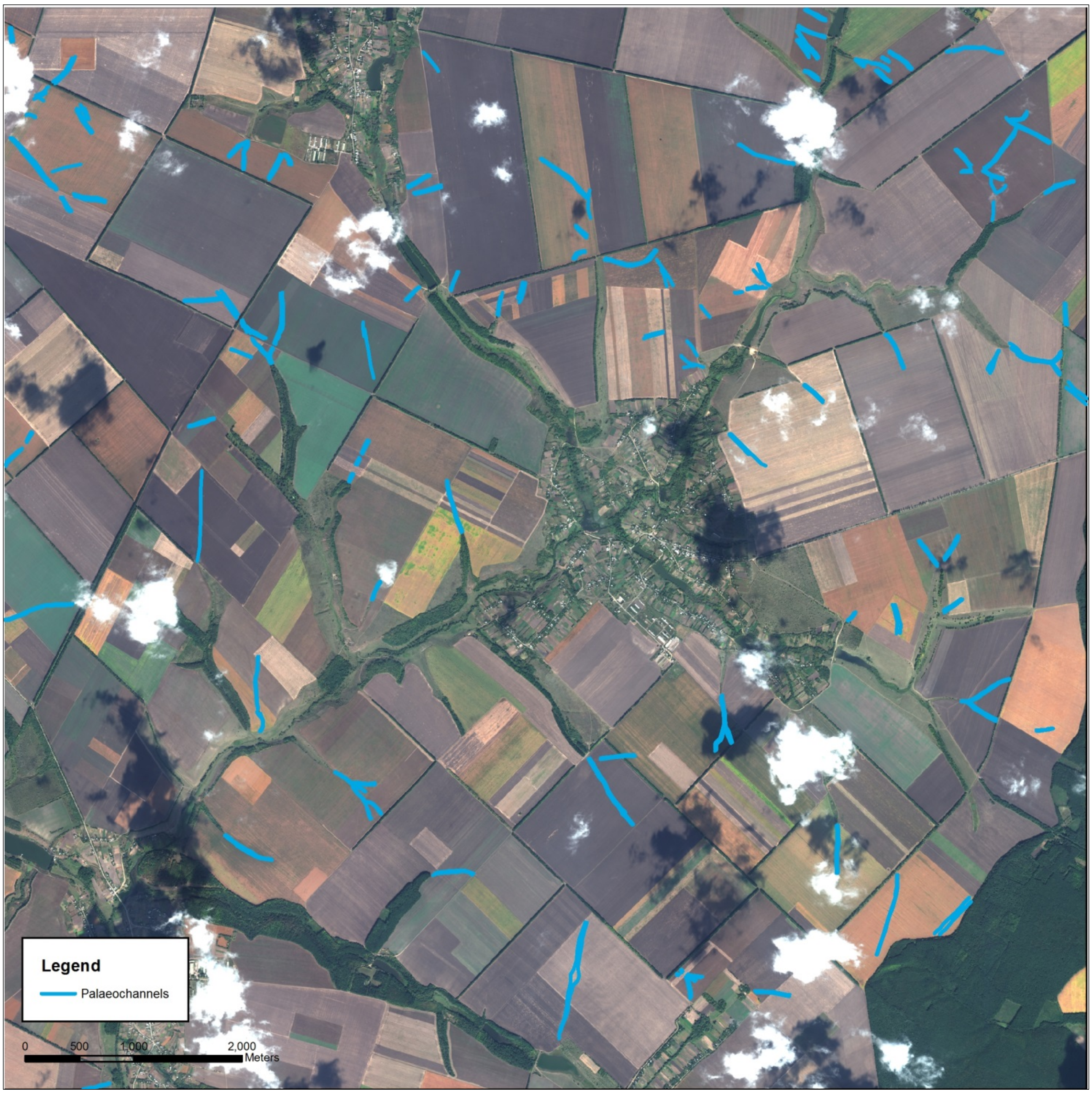


Fig. 4.6. Distribution of anomalies interpreted as traces of a palaeo-channel network, the Nebelivka micro-region.

As for the case of Nebelivka, where the site extends across more than one field, it was possible to verify how the visibility of the anomalies, indicating the Trypillia settlement, decreases on the cultivated parts. Moreover, the analysis of the archaeological deposit depths across the site shows how the features in the northeastern part are more visible because the anthropic horizon is closer to the current ground surface. A combination of tillage erosion and water run-off arguably explains the high visibility of features on the satellite image in the north-eastern part of the site, in correspondence with the ground surface sloping downhill towards the river valley bottom (Fig. 4.8). Another WorldView-2 image, taken on 14 April 2008, shows that in crop-free conditions also the southwestern part of the site is quite visible; this is because features appear as soilmarks. Nevertheless, the higher visibility of the northeastern part of the settlement is confirmed, as the run-off effect is the major contributor to the shallowness of the topsoil. For another Trypillia megasite

(Perehonivka, Cherkassy region – 7 km south of Nebelivka) we have a double coverage of WorldView-2 images; both panchromatic, one taken in April 2008 and the other in September 2011; the whole site (25 ha) lies within a single field, therefore the land use evenly affects the visibility of all the features constituting the settlement (Fig. 4.9). The comparison of the two images clearly demonstrates that while the April 2008 crop-free image shows the site in its entirety, the September 2011 image does not even suggest the presence of buried features as the field is totally covered in crops and nothing is visible.

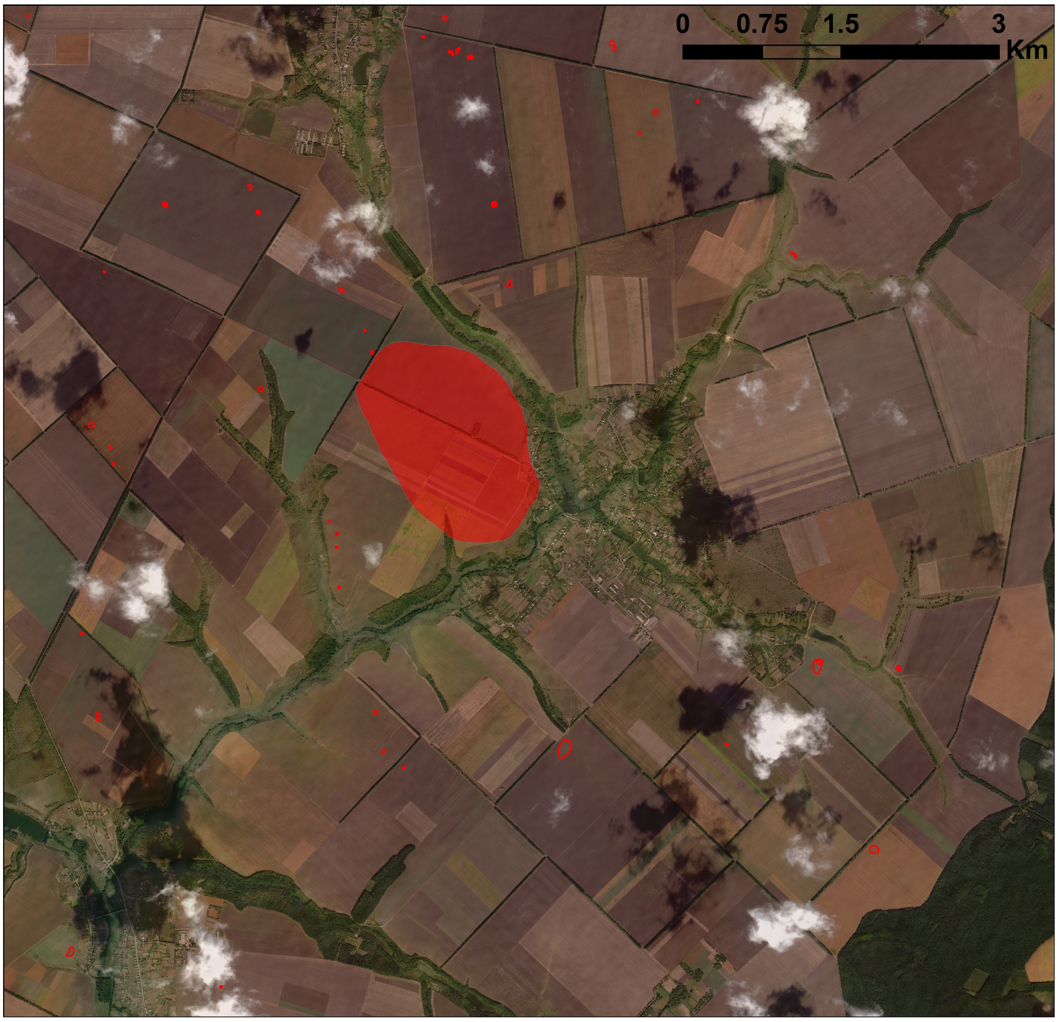


Fig. 4.7. Anomalies mapped on the WorldView-2 pansharpened multispectral 8-band (0.46 m) satellite image, which have been interpreted as having anthropic origins.

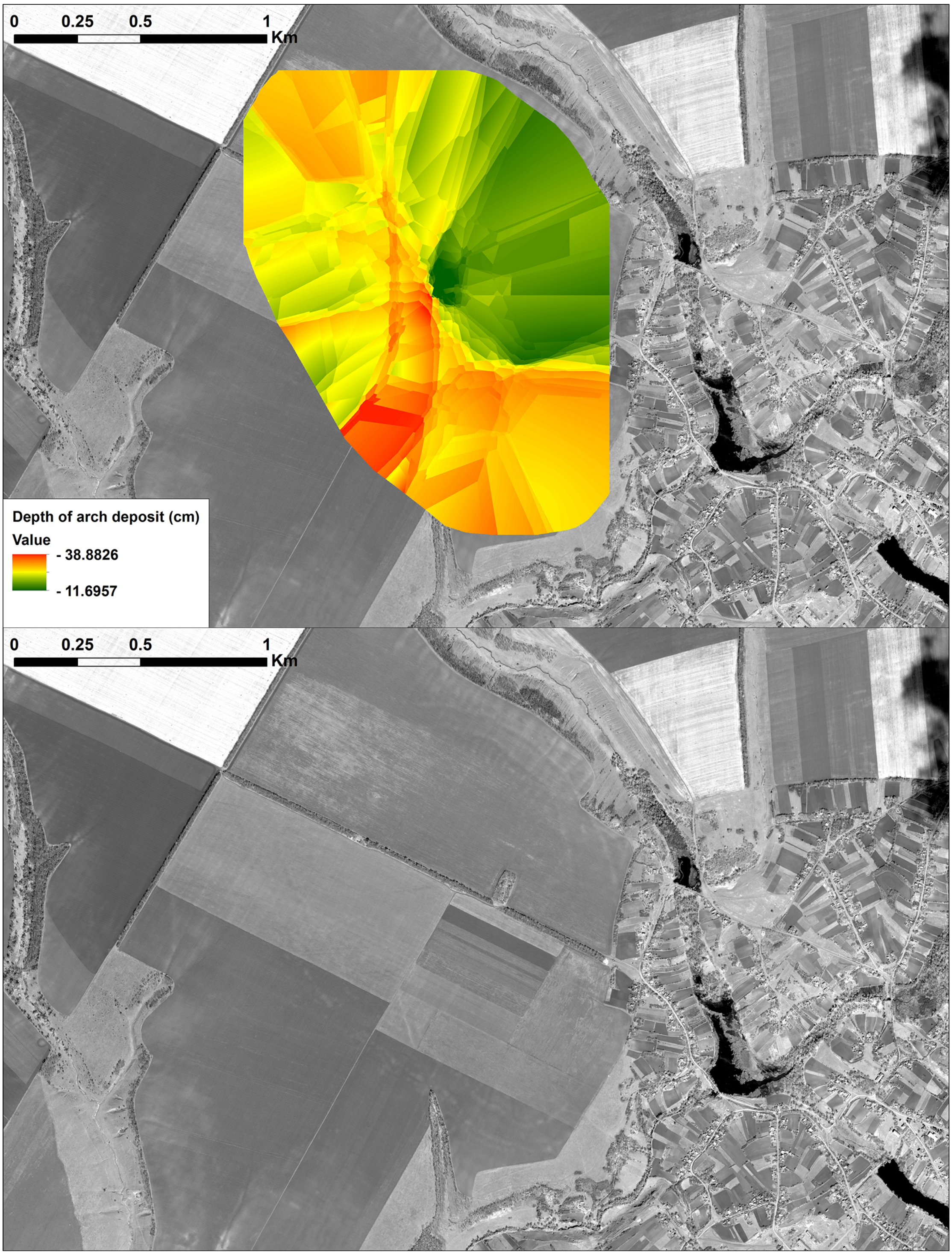


Fig. 4.8. Shallow depth of the top of the anthropogenic deposit on the northeastern part of Nebelivka, allowing a better visibility of the anomalies compared to the rest of the site.

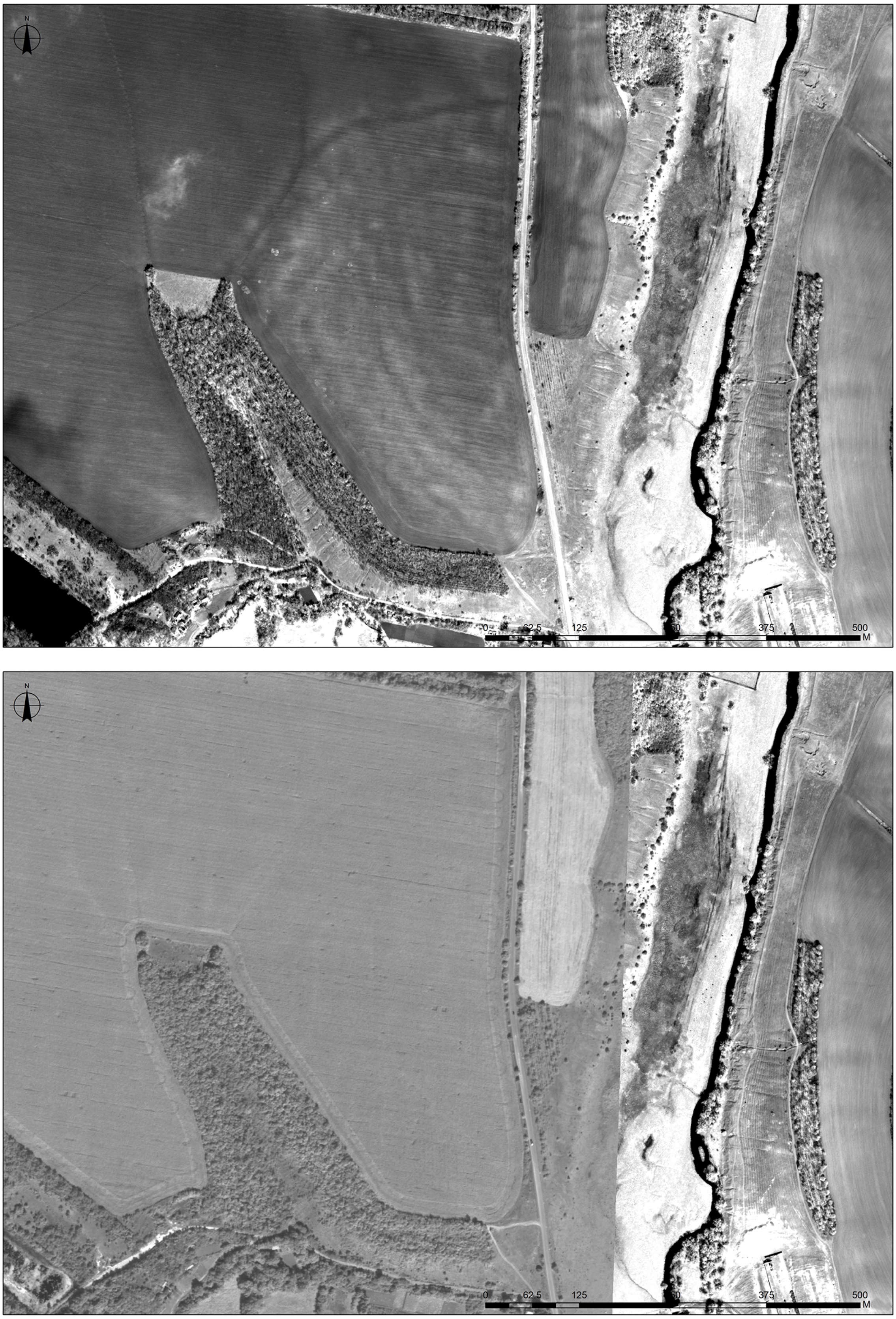


Fig. 4.9. Two views of the Trypillia site of Perehonivka (BII): clearly visible on a crop-free field conditions (top) and totally invisible when the field is cultivated (bottom).

The results of the assessment show the way in which archaeological remains of Trypillia settlements can be detected and mapped on satellite imagery under very specific geomorphological and vegetation conditions. Moreover, the ploughing and natural drainage erosions contributed significantly to archaeological visibility in remote sensing data; hence, this may explain why historical images like CORONA, which were taken 50 years ago, are not well suited for the identification of Trypillia sites in this area. Paradoxically, erosion through intensive and deep ploughing over the last century did not just destroy the sub-surface archaeological remains, but helped to make them more visible on the satellite imagery.

Since the visibility of archaeological features in this area, as cropmarks, is very poor, the most effective image processing techniques involved the enhancement of visual capacity for distinguishing features of interest from the background. A number of procedures have been tested and the results showed how a PCA applied to the full spectrum of 8 bands slightly enhanced the visibility of most of the features, but did not show more traces than a standard natural colours display (Fig. 4.10). A decorrelation stretch applied to the RGB bands significantly enhanced the visibility of the anomalies, but no extra features could be detected compared to natural colour visualization. Finally, a decorrelation stretch using the near IR - 1 (band 7), red (band 5) and yellow (band 4) wavelengths gave the best result both in terms of features visibility of anomalies detected (Fig. 4.11). The number of features detected and mapped, though, has not increased, meaning that all the anomalies are potentially visible on the natural colour stretch. This outcome has to do with the particular sensitivity of the near infrared wavelength to soil moisture level, which is affected by the presence of buried archaeology.

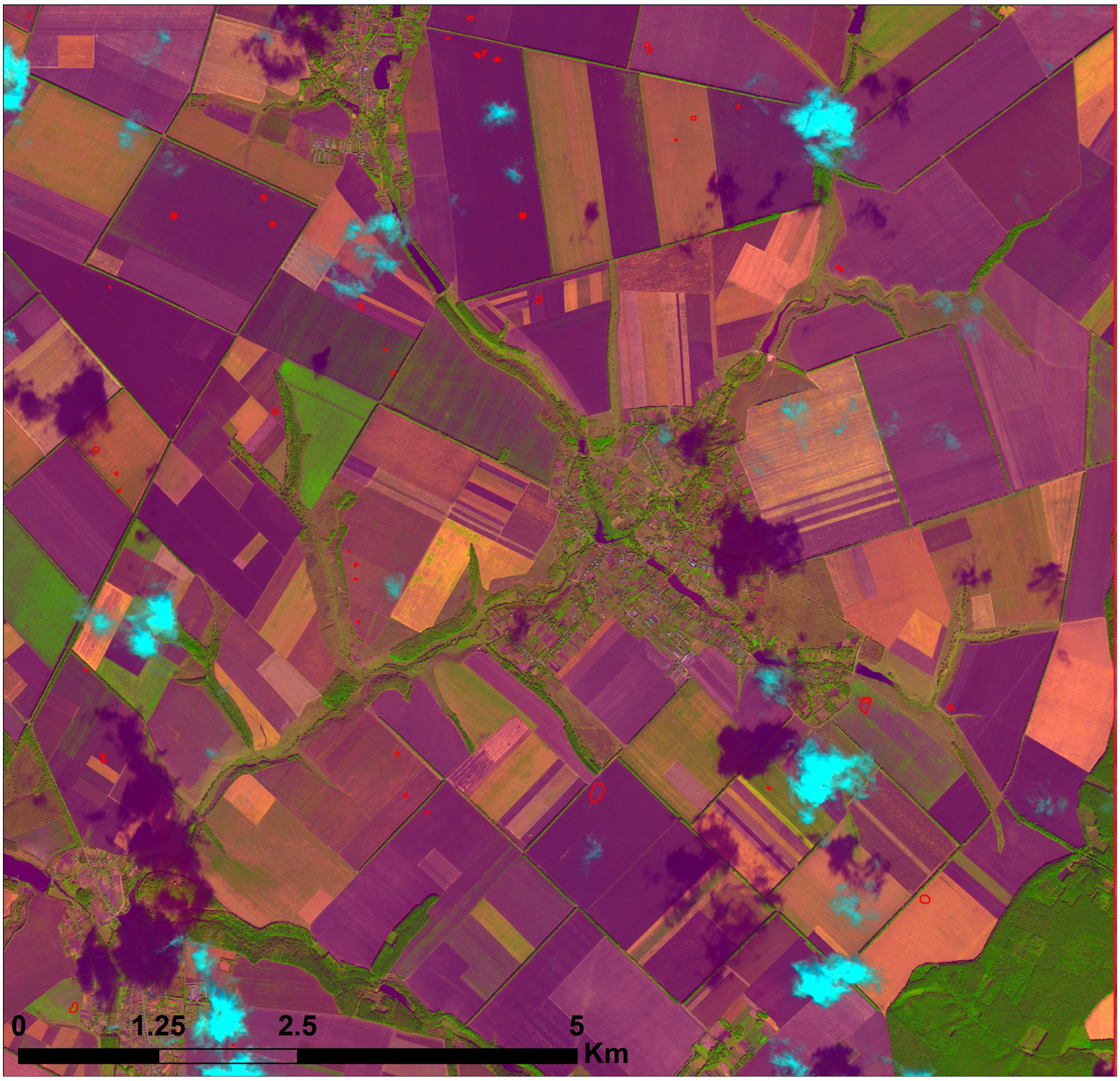


Fig. 4.10. Image enhancement Principal Component Analysis (PCA) performed on all the 8 pansharpened bands of WorldView-2. The band combination displayed is R: band 3, G: band 1, B: band 2.

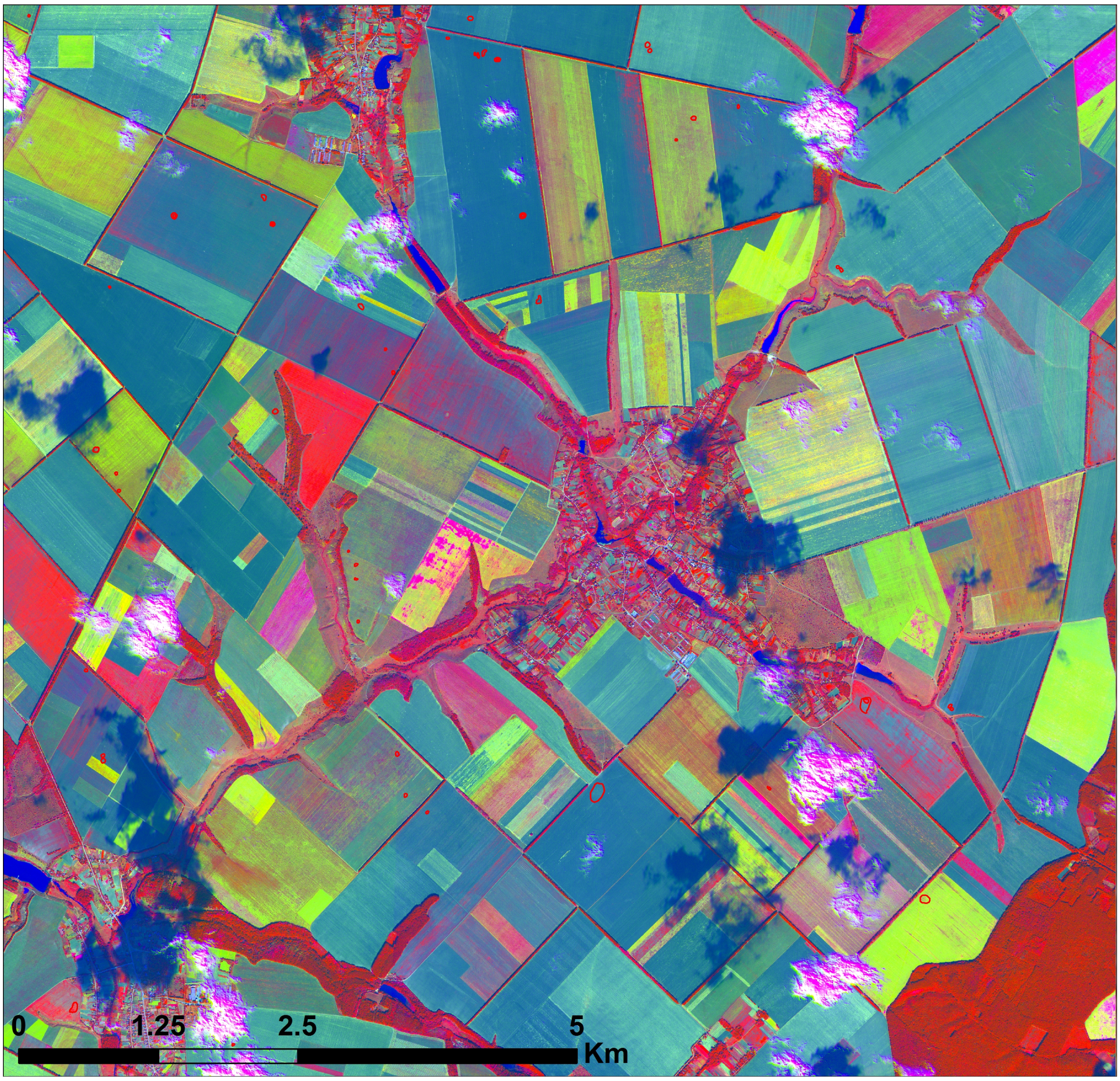


Fig. 4.11. Decorrelation Stretch image enhancement applied to all the 8 pansharpened bands of WorldView-2. The band combination displayed is R: band 7, G: band 5, B: band 4.

The systematic photo-interpretation of the WorldView-2 imagery resulted in different archaeological features being mapped both within the Nebelivka hinterland (5 km radius) and within the macro-region (25 km). There are relatively similar patterns in terms of object types detected in the two areas, but a significant difference regarding the presence of Trypillia evidence. The majority of the features can be interpreted as traces of an old hydrological system constituted by dry gullies and relict paleo-channels connected with, still active, major rivers (Fig. 4.6). The scenario represented by these natural features suggests a more intricate network of rivers and streams, which was active in the past. Unfortunately, there is no chronological evidence to date the older features [16], although we can argue that the fact that one of the palaeo-channels runs across the two outer circuits of the site in Nebelivka and

[16] No OSL dating has been scheduled within the project for these features.

that the layout of the dwellings respects its limits, could suggest that it was active during the occupation of the Trypillia mega-site (Fig. 1.4).

Other archaeological features have been mapped within the Nebelivka hinterland and mostly they refer to burial mounds (kurgans), which can date from the Early Bronze to the Late Iron Age. Burial mounds preserved differently as they are situated in currently cultivated fields and therefore ploughing activity levels some of them out. Their height varies from 4-5 m to 0.30 m but even the subtler ones can be detected and mapped on satellite imagery (Fig. 4.12). The eroded mound tops reveal the subsurface soil composition which has a spectral signature distinguishable from the background field.

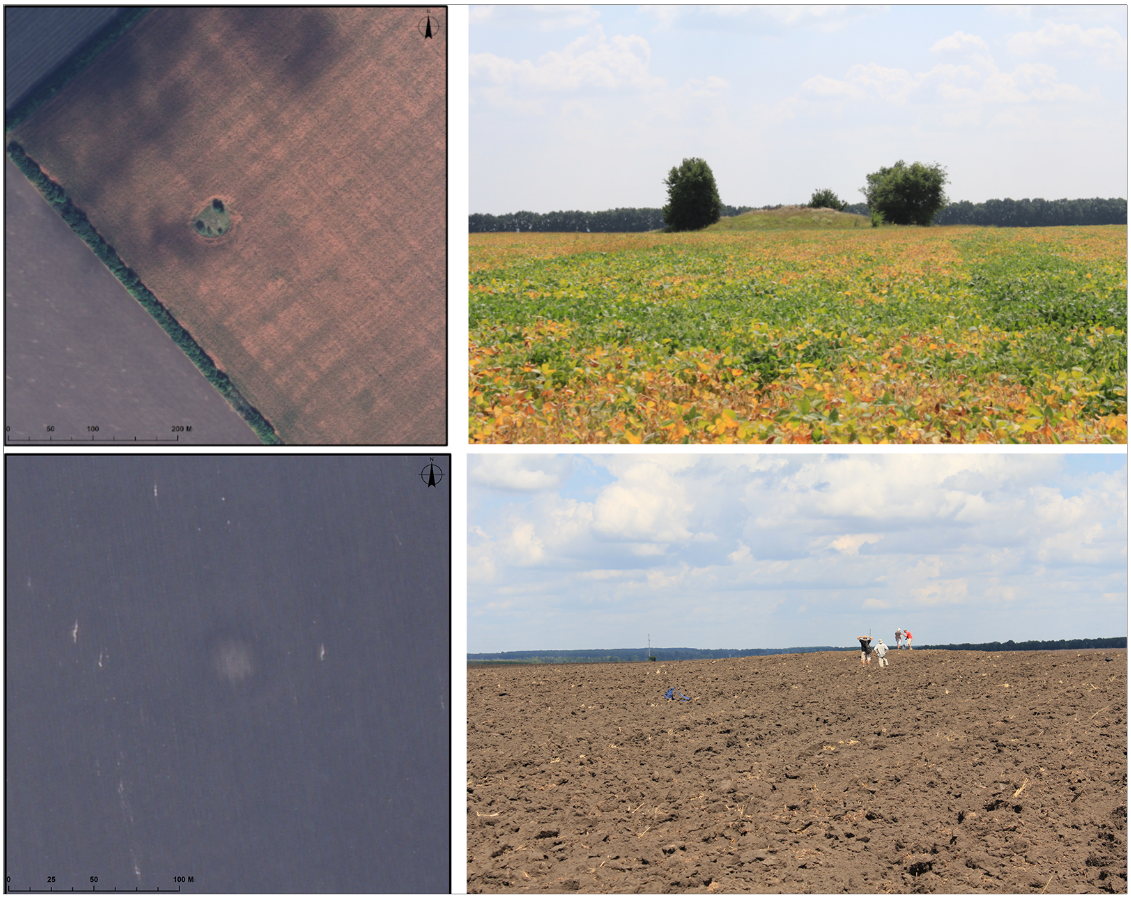


Fig. 4.12. Comparison between two extreme examples of kurgans as they appear on the WorldView-2 satellite image and on the ground.

Kurgans are one of the major categories of archaeological evidence that marks the territory under study at all scales. They are primarily situated on natural ridges or high topographical zones and mostly occupy inter-fluvial areas (Fig. 4.13). The mapping of the macro-region of Nebelivka yielded around 800 anomalies, which can be referred to as burial mounds of different time periods (with 95% certainty). Although their shape is quite discernible from the background across different land uses, there are a number false positives – i.e. anomalies which originate from modern human activities such as spoil heaps of agricultural waste, that resemble the shape and the topography of burial mounds.

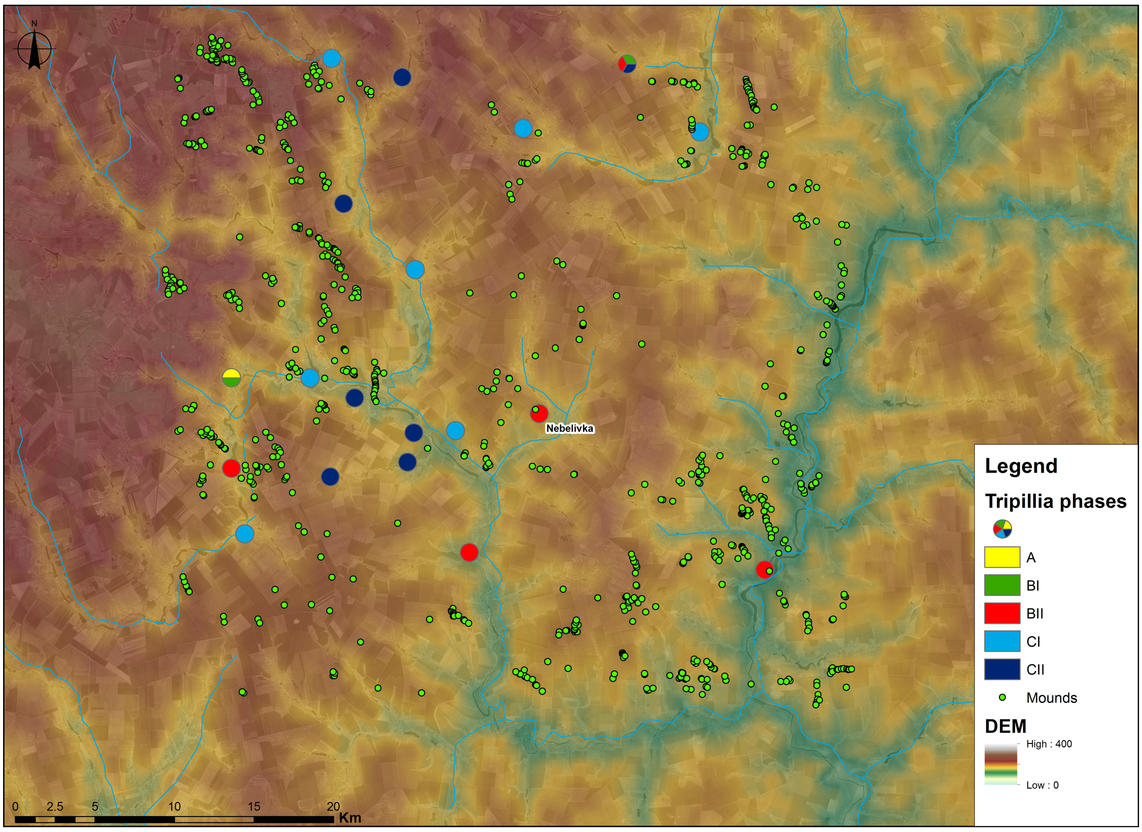


Fig. 4.13. Distribution of all the anomalies that can be interpreted as burial mounds (= kurgans) mapped within the Nebelivka macro-region.

Trypillia mega-sites are quite visible on the panchromatic WorldView-2 image, although, as already mentioned, only in crop-free conditions. More Trypillia sites have been mapped in the macro-region and the patterns of their visibility on the imagery are similar to Nebelivka's, where the parts of the sites laying on the slope towards the river valleys are considerably clearer (Fig. 4.14). Sites like Suschivka, Yatranivka and Volodymyrivka present a similar layout as Nebelivka with two outer concentric circuits of dwellings and radial rows leading to the "empty" centre; they are all situated in comparable geo-morphological locations at the junctions of two river valleys or along a sharp river bend. The run-off areas show the archaeological remains more clearly then the top of the field where the sites are nested.

Fig. 4.14. Comparison between the visibility of four Trypillia megasites on the WorldView-2 panchromatic image.

Sites like Maidanetske and Taljanki (the biggest in extent among Trypillia) are not as obvious to detect on the imagery, probably due to two main factors. The first is that, arguably, the archaeological deposit is deeper compared to the other sites, therefore the presence of buried remains does not affect soil moisture content enough to produce a clear anomaly. Secondly, the simple fact that one single image cannot guarantee the best condition for a feature to be identifiable and mapped clearly.

The results of the remote sensing analysis show how only 8 out of 24 sites are visible (even partly) on the images within the macro-region; and only 15 out of 500 sites recorded in the whole Ukraine.[17] However, smaller sites like Apolyanka can also be mapped, if the land use conditions are favourable (Fig. 4.17). This site is an example of very low-density settlement occupation, where the mean average distance between dwellings is nearly 40 m. From the photo-interpretation, the structures can be detected and mapped individually; therefore, we can argue that the anomalies on the image represent ***in situ*** archaeological features. This can be argued also for the mega-sites where the more regular planning shows clusters of dwelling nested one next to the other, thus manifesting, on the image, as a continuous linear feature. In the case of mega-sites the high proximity of archaeological remains produce an uninterrupted anomaly, but single structures can still be detected from the surface scatter of potsherds and building materials, which is very confined around each structure (Roe 2011) (Fig. 4.15-16).

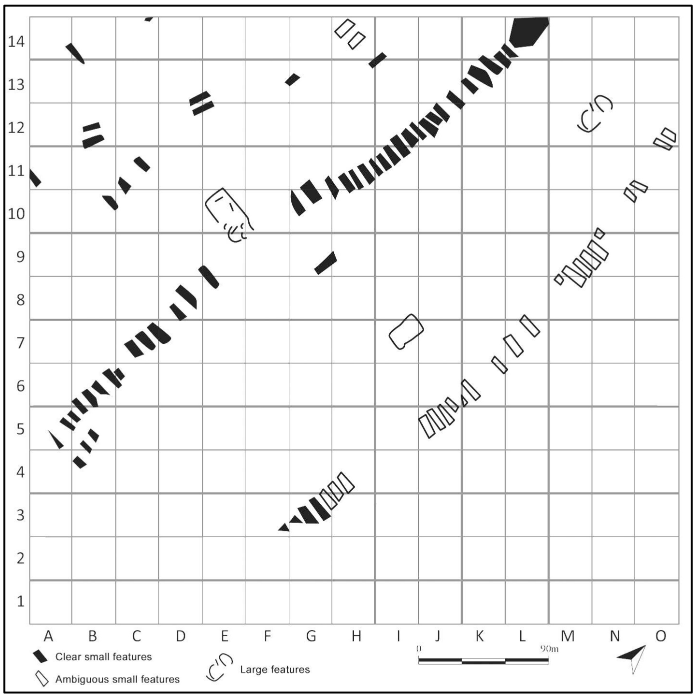


Fig. 4.15. Interpretation of the geomagnetic survey. Southeast corner of Nebelivka. Visible are parts of the two concentric circuits of houses. (Roe 2011).

[17] The assessment was performed with Google Earth which provides a good range of images, taken in different times of the year for different years.

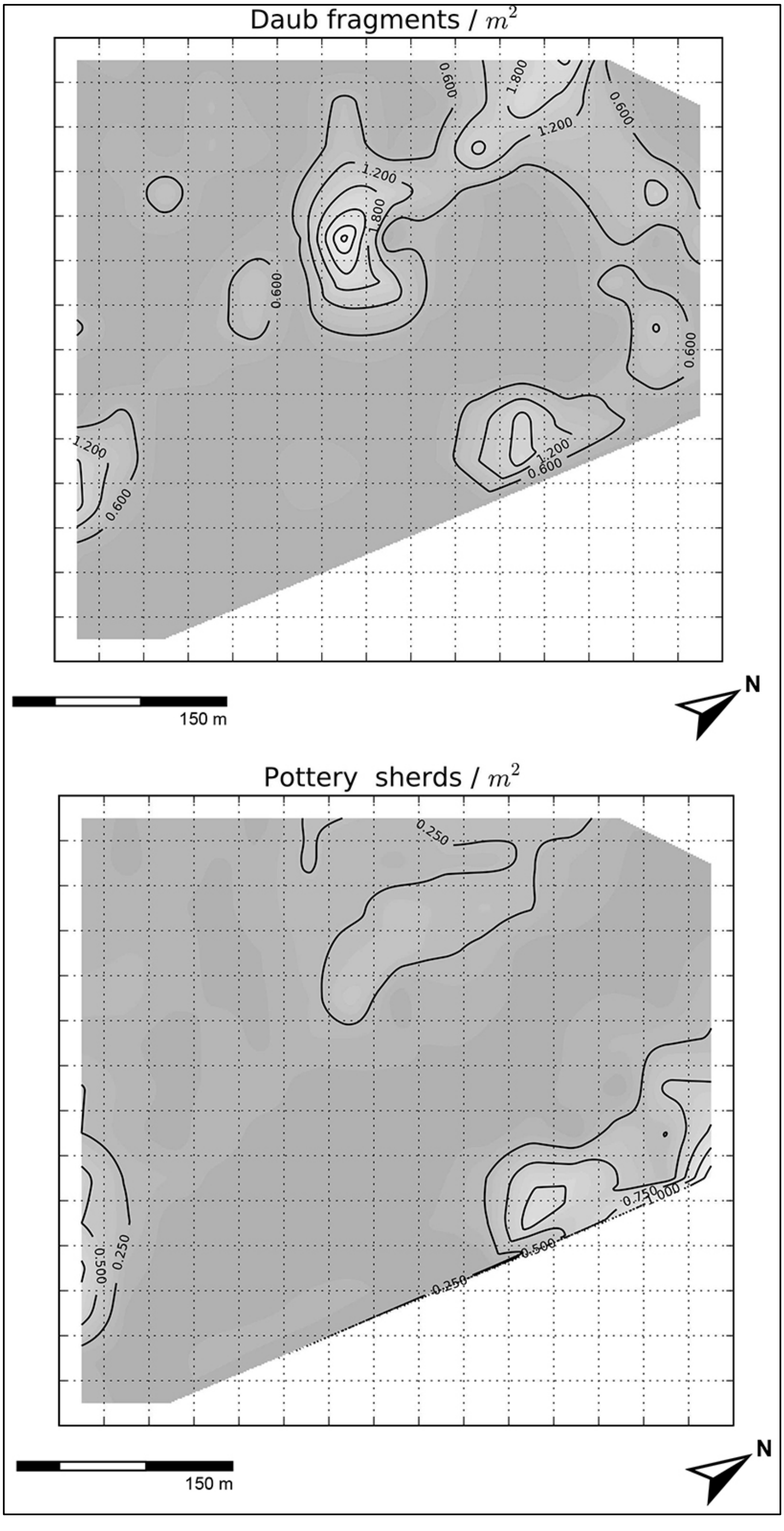


Fig. 4.16. Interpolated contour plot of daub (top) and pottery (bottom) densities by number of fragments. (Roe 2011).

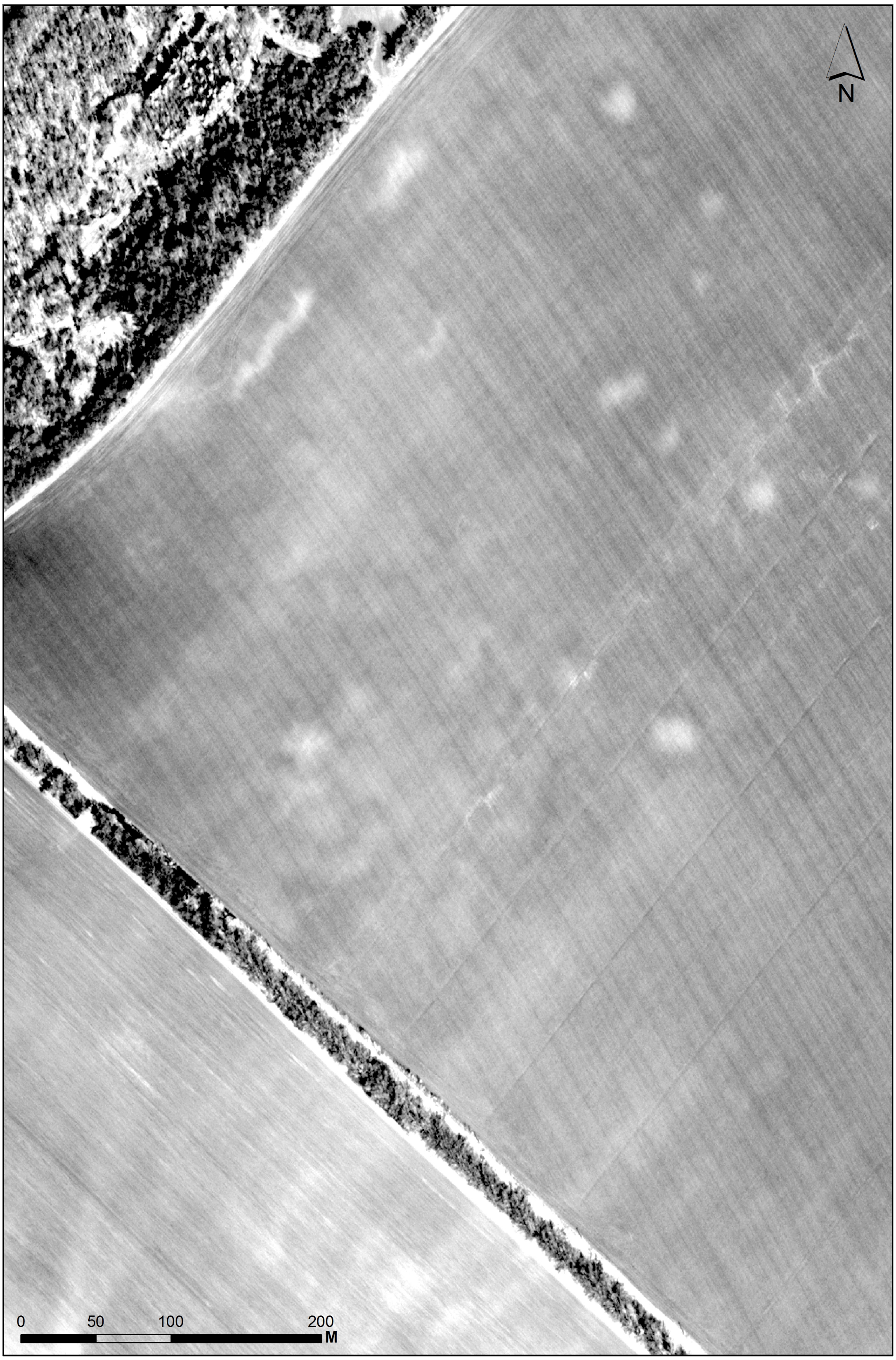


Fig. 4.17. Anomalies attributable to Trypillia houses at the site of Apolyanka (CI). WorldView-2 panchromatic.

Additional sites, dating to the Early Middle Ages, have been mapped in the micro-region, although their anomalies are heavily disguised by the background noise of the image. These sites are located at the junctions of water courses (like most sites from all time periods) and they average about 50 m (Std. Dev.) in distance from water bodies. The majority are situated in the strip of water run-off along riverbanks, and the water drainage effect results in dark linear features running along the slope and bright inter-feature areas representing outcrops of the clayey chernozem C horizon (Fig. 4.18). This natural process of water erosion affecting the river bank slopes prevents a clear detection of archaeological features, these being washed away. For this reason, the potential for site mapping from satellite imagery is very limited, as natural features can be mistaken for archaeological ones. However, collection of surface material during field survey is still the main source of site reconnaissance.
A further explanation of the riverbank erosion process might be attributable to a palaeo-cryogenesis effect which produced, during the Late Pleistocene and the Holocene, soil frost cracking, lifting and sliding of soil polygons into the river valleys. This might also explain the palaeo-valleys infill process (Alifanov et al. 2008).

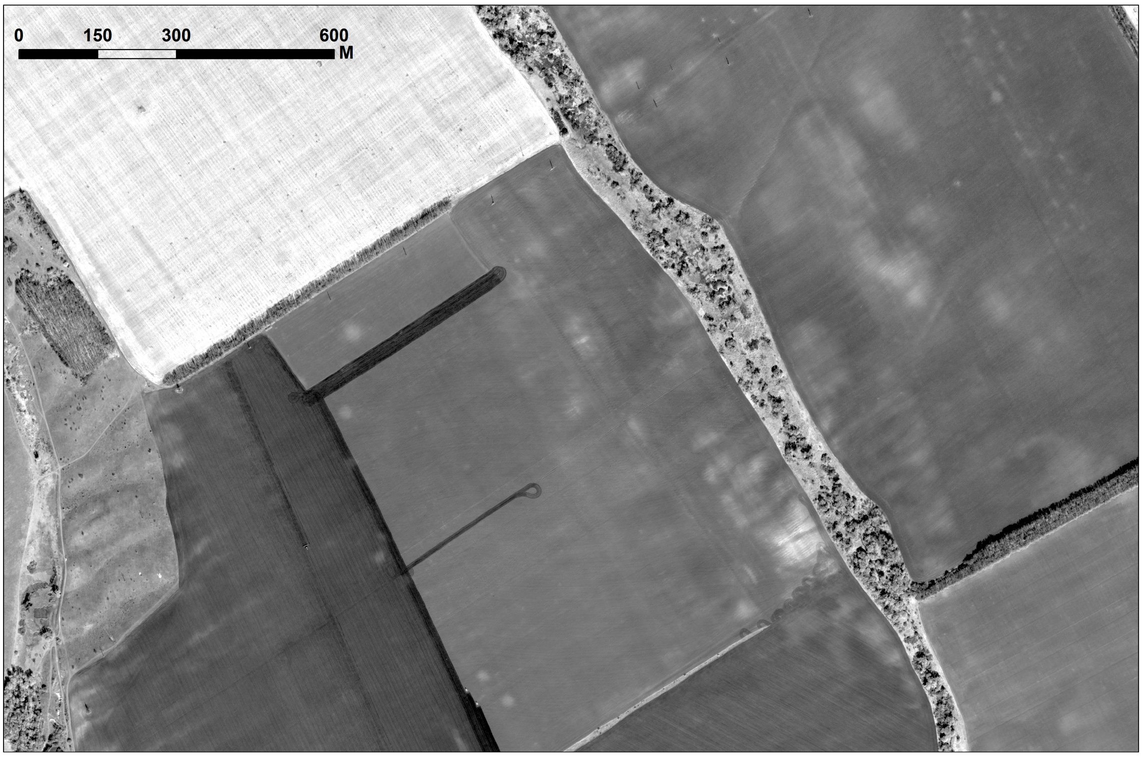


Fig. 4.18. Outcropping of the soil C horizon. As seen on satellite image.

Overall, the remote sensing analysis has been shown not to be the best way for site reconnaissance in the Nebelivka micro-region. This is due to several factors, but mainly to the limited availability of satellite datasets. In fact, a wider range of land uses, different times of data acquisition and different sensors could help in overcoming some of these limitations. The tendency is now to use multiple data sources combined in order to produce images containing a high level of information for archaeological applications. Only the availability of more data and a more accurate assessment of the best temporal window for data acquisition can improve the applicability of remote sensing analysis in this area (Aqdus et al. 2012; Agapiou et al. 2013).

The great contribution of Very High Resolution (VHR) remote sensing datasets resides in the direct correspondence between the anomalies and the archaeological features, which allows for a better estimation of the site size and occupation density. Individual structures are visible as ***in situ*** features, rather than homogeneous halos representing surface and sub-surface scatters of material. Therefore, site layouts, the number of dwellings and their orientation, and site limits can be recorded and estimated more accurately (see section 4.5.2.2 for the use of satellite imagery to assess site size).

4.3.4 Summary of main results

This section 4.3 produced some major results that make a remarkable contribution to Trypillia archaeology and are worth highlighting. The main contribution of this section is in offering the first thorough assessment of the remote sensing potential for the recovery of Trypillia settlements, which produced the following results:

1. The confirmation that CORONA images, although ideal for archaeological mapping in other areas, like the Near East (= arid environment), are not useful for detecting and mapping Trypillia sites.

2. There are limited conditions of land usage and types of imagery that are favourable for the mapping of Trypillia megasite (and others). Mostly, remote sensing is not the best tool for site recovery.

3. Riverbanks and water run-off areas have the best potential for either showing sub-surface archaeological features or hindering their visibility because of similar spectral signatures derived by the eroded soil.

4. Satellite imagery has great potentiation for the mapping of burial mounds and palaeo-channels.

4.4 Archaeological survey: a background overview

The history of archaeological field survey dates back to the 19th century and since then it has been developed, adapted and updated along with broader research agendas (Renfrew and Bahn 2000, 74). Initially, field survey was an exercise intended to discover new sites and locate them on a map. More recently, it has turned into a specific method of archaeological investigation, with an independent branch taking shape under the term ***Surface Archaeology*** (Bower 1986, 21; Sullivan III 1998).

Over time the informative potential of Surface Archaeology has increased enormously thanks to the development of new methodologies capable of extracting as much information as possible from material scatters on the ground. Archaeologists assessed the reliability of surface assemblages as proxies for subsurface remains, so that non/partially-destructive analyses can yield significant results for synthetic interpretations of the archaeology (Downum and Brown 1998). Even though the variables to consider are numerous and an overall conclusion is hard to achieve, it seems that the informative potential of surface scatters can be quite considerable, especially for site and inter-site study. Conversely, for small scale intra-site investigations it can be difficult to estimate the respective subsurface deposit, although a larger sample can give useful insights on the archaeology at the site level (Redman and Watson 1970, 285; Johnson 2014, 288). Types of soil, land uses, taphonomic processes, weathering, agricultural regimes, plough-zone thickness, types of archaeology, depth of the archaeological horizons, geomorphological conditions, deposition processes and finally methodological biases affect the analysis of surface artefacts (Johnson 2014, 276-277), however the non-intrusive and non-destructive nature of field survey provides the opportunity to investigate broader sample territories.

Surface archaeology has been common practice within archaeological projects since the beginning of the 20th century, when extensive field surveys have been conducted in the Mediterranean basin (Lehmann 1939) and at a smaller scale, but covering all time periods, in England (Fox 1923). Thereafter, since the 1950s and 1960s, field surveys have been included systematically in research agendas, and extensive data collections have been conducted in Central America (or Mesoamerica) both at a regional scale (Willey 1953) and at urban scale (Millon 1964).

The Diyala Basin Archaeological Project represents one of the earliest and pioneering survey projects, introducing a multidisciplinary approach - including the use of remote sensing - and focussing on the long-term history of human-environment interactions, carried out in support to programme of agricultural development in the territory of modern Iraq (Adams 1965).

A pivotal and ground-breaking project, in terms of detail analysis of the surface material, has been carried out by Ward-Perkins in the territory north of Rome (*Ager Veientanus*). Extensive field survey conducted alongside material analysis resulted in a detailed narrative of the landscape and settlement patterns in the area from the Late Prehistory to the Middle Ages (Kahane et al. 1968).

As a natural follow-up, the South Etruria Project evolved into an extensive regional scale survey, which developed new methods and technologies supporting the fieldwork (Potter 1979). The massive amount of data produced has been later studied and interpreted within the Tiber Valley Project, thus resulting in a reorganization of the data into a GIS platform and database, as well as a more accurate reinterpretation of the material collected during the previous two projects (Patterson 2004).

Between the 1970s-80s the issue of how useful survey data are, and the way they have been collected so far, was addressed (Cherry 1983, 379). New methods of data collection were proposed in order to overcome problems such as the coarse chronological resolution, the simultaneity of sites, the visibility and spatial definition of sites, and the internal organization of settlements. The proposed “solutions” to these problems consisted of a general enhancement in the intensity of the survey. This raises the number of sites detected, increases the potential for defining sites’ extent, allows for the collection of more diagnostic material, thus leading to a more fine-grained chronology and a more detailed mapping of surface material density at the intra-site level (Cherry 1983; Plog et al. 1978; Ammerman 1981).

Two seminal volumes (Keller and Rupp 1983; Jameson et al. 1994) showed how much field survey started to be fundamental in archaeological research agendas and could contribute as such to delineating regional and long-term narratives. The chronological resolution still remains quite coarse. If we consider the three time scales described by Braudel - *evenement*, *conjoncture* and *longué durée* (Braudel 1995), archaeological survey can only contribute to the last two (Barker and Lloyd 1991, 1). For this and other limitations, mentioned above, the need for in-depth investigations, such as excavations, has been stressed by some scholars who deem that the evidence derived from survey data are too misleading and incomplete to be almost totally discarded for analytical and interpretative purposes (Hope Simpson 1977, 213-217). The Mediterranean basin has been extensively explored and new techniques and methods developed and adopted in order to make survey data more talkative in terms of providing information regarding short and long term settlement patterns and population trends.

Major projects like the Boeotia Survey have established standardized procedures for data collection (accurate sampling strategy) and data storing, introducing the systematic use of GIS and bespoke databases for survey material and novel practices of investigating the off-site, thus contextualizing the site in a denser rather than discrete site map (Bintliff et al. 2007, 9-11).

As suggested by Bowen, the surroundings of a settlement or a site can contain scatters of “datable rubbish” resulting from ancient manuring activity using settlement waste (Bowen 1962, 6), therefore it is worthwhile investigating archaeologically the continuous spatial distribution of material scatters in order to define past land uses (Cherry 1983, 395). Wilkinson has developed a methodology for the investigation of ancient manured zones around archaeological sites in the Middle East (Wilkinson 1982). These studies prompted the development of the off-site survey investigations carried out especially in the Mediterranean and Near East areas (Gallant 1986; Bintliff and Snodgrass 1988; Wilkinson 1989).

The increasing number of regional surveys fostered inter-regional comparisons especially within the Mediterranean basin where field methodologies mostly developed towards long-term settlement patterns analysis. A number of syntheses have been published in order to gather data from different, present and past, survey projects, and the attention has been focussed on trying to merge and compare extensive (therefore less detailed) survey data with more recent intensive ones.

The POPULUS project, started in the mid 90s, focussed on developing new methodologies, by adopting a multi-disciplinary approach, to investigate long-term demographic patterns in the Mediterranean. The resulting volumes discuss the contribution of the different techniques like environmental reconstruction, GIS, remote sensing and field walking (Bintliff and Sbonias 1999; Leveau et al. 1999; Gillings et al 1999; Pasquinucci and Trément 1999; Francovich and Patterson 1999).

Other syntheses compared datasets from different regions in Italy (Attema et al. 2010), Crete (Gkiasta 2008), Central Greece (Bintliff et al. 2007), more broadly in the Mediterranean (Alcock and Cherry 2004), and for the Near East the seminal work by Tony Wilkinson (Wilkinson 2003).

Central Europe has not seen such quick development in field survey methodologies, but landscape-oriented projects started as national programmes in some countries. The Ancient Landscape Reconstruction in Bohemia (1991-1995) project started a systematic intensive field survey in targeted areas with two main objectives; to understand the Mesolithic/Neolithic transition in North Bohemia, and to assess the potential contribution of landscape archaeology to the reconstruction of the landscape destroyed by the mining activity (Zvelebil et al. 1993). The Polish Archaeological Record project aimed to develop a nationwide standardized protocol of site recording based on archival data and systematic field survey. Their fieldwork activity developed a methodology for data collection with the perspective of using the data as a tool for cultural heritage management (Barford et al. 2000).

The Neothermal Dalmatia project (1982-87) co-directed by Chapman and Batović combines traditional aspects of landscape studies, such as regional studies, environmental archaeology and spatial archaeology with social theory, thus drawing a new theoretical framework for understanding settlement patterns, by using the Manninan IEMP model of social power sources and organization (Mann 1986, 22-32) to interpret field survey and excavation data (Chapman et al. 1996, 9). This approach has been integrated within a GIS approach in the next big survey project conducted during the 1990s in Hungary (Chapman et al. 2010; Chapman et al. 2010; Chapman et al. 2010). The country has seen the development of major projects like the Hungarian Archaeological Topography which, with the aim of surveying all the archaeological sites in the whole country, published 10 volumes with data covering 10% of the nation at the end of the 1990s. Although the project did not rely on a standardized methodology for data collection, but rather improved and adopted modern survey techniques throughout the years, it has increased the number of known sites and set the basis for future directions of fieldwork towards a more systematic and intensive survey strategy.

The situation of archaeological field survey in the Ukraine is different since the country has been part of the Soviet Union, the Iron Curtain preventing it from having contact and exchanges with scholars from Western Europe. As such, it developed research methodologies and theories quite independently (Anthony 1995).

The contribution of the archaeological survey carried out within this research to Ukrainian archaeology, and in particular to Trypillia studies, will be discussed in the next section.

4.4.1 A new methodological agenda for the Ukrainian steppe

Since its beginning, the research agenda of Trypillia studies has not included systematic field survey investigations. The Ukrainian literature yielded very few reports on unsystematic surveys, carried out mostly as "supplements" of major excavations on Trypillia sites and mega-sites. Archaeologists mostly relied on local farmers' knowledge of Trypillia potsherd scatter locations in the fields, and most of the sites were found thanks to sporadic and unsystematic field surveys (in Russian *razvedki*).

Data recording systems have been developing, and the introduction of GPS has considerably improved the site location process in the last few years. Nevertheless, data collection methods do not follow procedures that are now standard in Western European archaeology and they are still inadequate for the level required by the scientific community. Ukrainian methods of investigations in the field have always been quite traditional and not inclined towards technological and methodological innovations. As aforementioned, Ukrainian archaeologists have been using remote sensing since the 1960s, although never developing a tailored strategy for the specific case of Trypillia sites. The same conservative approach has been pursued with field survey, so that a new methodological agenda for field investigation was needed.

The Danish-Dutch-Ukrainian Dzarylgaz Survey Project (2007-2008) first introduced in Ukraine "proper" field survey methods, including extensive, intensive and systematic investigations in the region around the lake Dzarylgaza and the hinterland of the Greek site of Panskoe I on the Tarchankut Peninsula, Northwestern Crimea (Guldager Bilde et al. 2012). Although the project's main focus was population dynamics and interactions during the Greek period between colonisers and indigenous people, the research adopted a long-term diachronic approach to the study of landscape (Guldager Bilde et al. 2012, 13).

As for Trypillia studies, no systematic investigation of the landscape has been carried out so far. Therefore, the fundamental impact of the TMP is the introduction of field survey methodologies into the Ukrainian research agenda, thus refining the understanding of settlement patterns dynamics in the forest-steppe belt in continental Ukraine before, during and after the Trypillia period.

In this specific research, field survey has been conducted for three main reasons: (1) to establish patterns of archaeological evidence in the off-site domain of a Trypillia mega-site, both during the occupation of the settlement and in other time periods – this information will help in understanding the complexity of the site formation, development and abandonment; (2) at a smaller scale field survey data has been used to assess the information, coming from the literature, regarding site locations and sizes – since the majority of site sizes reported by the literature are based on surface collection, it was vital to cross-check the potential of the surface scatters as proxies for site extent estimation; (3) to ground-truth the results of remote sensing mapping – it is essential to check the number of features mapped from satellite imagery in order to establish the reliability of photo-interpretation and to assess the potential of the different types of datasets in the specific territory.

In the following sections these three strategies will be discussed as they have been used in the field, and their contribution to the research elucidated.

4.4.2 Trypillia off-megasites: inter-fluvial and peri-fluvial investigations

During the first season of fieldwork in 2009 a partial coverage of the northeastern part of the settlement represented the first assessment of the potential and reliability of the surface material for archaeological survey (Roe 2011). The results showed that the archaeological material scattered on the surface is quite representative of the sub-surface remains in terms of density distribution. As discussed in section 4.3.3, the depth of the archaeological deposit varies across the site, but overall it ranges between 12-40 cm thus sitting within the plough-zone. This guarantees a high visibility of both potsherds and building material that are brought to the ground surface by deep ploughing activity which occurs annually – the chernozem is in fact such a fertile soil that it does not need long resting periods. Since the megasite extends from the river bank, across two fields, to another branch of the river, this first survey served as an assessment of the potential for recovering archaeological (or at least Trypillia mega-sites) sites both along rivers – where water erosion is affecting the topsoil thickness – and in inter-fluvial areas - where someone might expect the archaeological horizon to be deeper than the plough-zone.

The results of the survey have been crosschecked with geomagnetic data and showed a clear correspondence between surface scatters (daub more than potsherds) and distribution of anomalies produced by the presence of sub-surface structures (Roe 2011, 28) (Fig. 4.15-16).

Starting from the assumption that general visibility of buried archaeology on the ground surface is high, a plan of field investigations has been designed accordingly.

4.4.2.1 A combined adaptive sampling strategy: first assessment of site recovery potential in the Nebelivka hinterland

Since neither systematic nor designed field survey has ever been conducted in continental Ukraine (especially within Trypillia studies), I deemed it necessary to plan a sampling strategy targeted at assessing the potential for recovering archaeological sites in general and to investigate the hinterland of a Trypillia megasite (Nebelivka). The sampling strategy is a fundamental step in the research design and key to understanding the data collected, particularly how representative and reliable they are "***within the bound of their (researchers) restricted time and monetary resources***" (Binford 1964, 427; Redman 1987).

The strategy was a combination of informal and formal sampling (Orton 2000, 2).

The first, informal, choice was to investigate a radius of 5 km around the mega-site to verify the presence of Trypillia sites and to assess the general site locations for all time periods. The choice was to conduct a block survey covering the entire extent of each field thus having an even and solid sample of the landscape. Considering the limited amount of time available a random coverage of fields with higher ground visibility has been sampled in order to have the most reliable results from a single survey. The rotating agricultural regime guarantees that every year every field changes crops; hence the influence of modern land use on post-depositional processes and preservation of surface scatters is randomized. Therefore, we can consider the choice of surveying one field against another one independent from their influence to the potential of recovering surface finds aside the current ground visibility at the time of the survey. We can then say that the choice of surveying only the fields with high visibility represents a formal random sampling with the highest potential to recover archaeological presence in a single survey season. Furthermore, this strategy allowed for the assessment of sites recovery on both inter-fluvial and peri-fluvial areas of different slope and aspect.

Embracing an adaptive 'non-site' sampling strategy (Thomas 1975), where the smallest unit of investigation is the artefact and not the site as whole, the first survey season has focussed on collecting all the materials scattered on the surface of the walked field and plotted them using a hand-handle GPS device[18] (Fig. 4.19). This gave an idea of how the finds were distributed on the surface and, therefore, helped the definition of site from off-site scatters. Students participating in the field season carried out the survey, under my supervision, by walking transects across each field. After a first test of different spacing between transects it turned out that 20 metres is

[18] See Appendix B for primary data.

the most cost effective distance, which allows spotting the different range of site scatters found in the surveyed area. The definition of site scatter has been broadly discussed since the beginning of archaeological surveying (Gallant 1986; Schofield 1991; Bintliff 2000; Waagen 2014), and numerous methods have been established in order to achieve the best results. In the case of Ukrainian ploughed fields, the definition of site scatter from off-site distributions of material resulted quite straightforwardly from the outcome of the first season of field walking around Nebelivka.

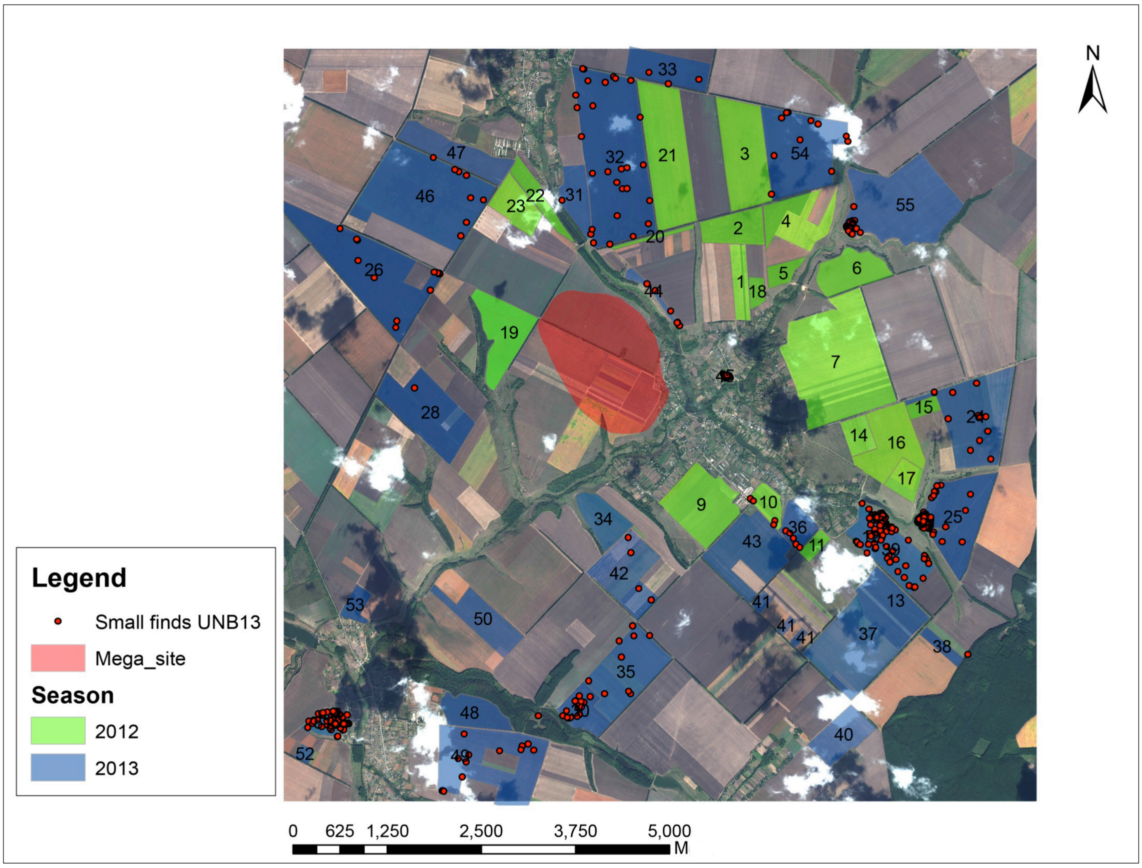


Fig. 4.19. Distribution of small finds recovered during the first season of fieldwalking in the Nebelivka micro-region.

The adopted regular grid allowed for clear recognition of the concentration of potsherds defining a site against the average potsherds density per ha. Field 25, for instance, has an expected potsherd density of 2.6 per ha, whereas in the southwestern corner we identified a cluster of surface material with a density of 60 potsherds (88% of the total number of potsherds found within the field limits) per ha. Another example is field 39 where the expected potsherd density is 1.6 per ha, and the site identified on the northern corner presents a density of 32 potsherds per ha. If we compare surface finds densities across the 30 different surveyed fields we can clearly see how the four fields containing archaeological sites stand out, thus providing a threshold of 1 sherd per ha for land units containing scatters definable as sites (Fig. 4.20).

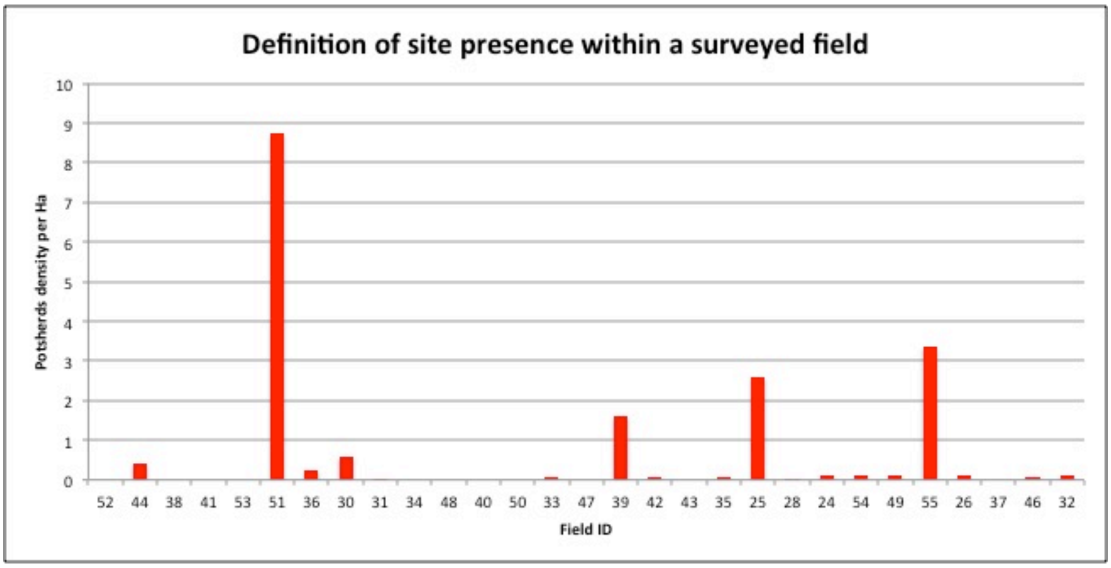


Fig. 4.20. Chart showing sherd densities across the surveyed land units.

The data collection followed an adaptive cluster sampling (Orton 2000, 34-38). The starting sample unit is the regular transect until a high level of material concentration is found. Thereafter, the walking strategy adapts to the local variability of potsherd density by investigating the adjacent neighbourhood until an expected density is found again. The localized anomaly in material density corresponds to what we defined as a site. The limited amount of time available did not allow any evaluation of the nature of these sites, although most of them returned mainly pottery and rarely any building material.

The following sampling tactic builds up on this first assessment and aims at confirming site locations, thus achieving a more accurate estimation of intra-site organizations and establishing a methodology to document site extents.

4.4.2.2 Perifluvial survey investigations

The results of the first season of field survey suggest that archaeological sites, overall, sit on riverbanks at the junction of two or more river branches, very close to watercourses. The interfluvial areas are mostly free from settlements. The outcome of the first assessment suggested the planning strategy for further investigations of the Nebelivka hinterland. No Trypillia settlements were found within 5 km of Nebelivka, and very few (not more than 20) Trypillia potsherds were classified as off-site scatters. This result has multiple archaeological implications that will be discussed in Chapter 5. After surveying 2744 ha of ploughed fields, the four scatters defined as archaeological sites all present the same geomorphological settings, as mentioned above. Therefore, further investigations have been planned along major and minor watercourses, some still active, some dried out and currently used as pathways. Table 4.1 summarizes the main periods and cultural labels that relates to the material collected during the field survey.

Period or cultural label	**Dates**
Bronze Age	3000/2900 – 1050/1000 BC
Iron Age	1050/1000 BC – 2nd century AD
Cherniahov	2nd – 5th century AD
Slavonic (e.g. Scythians)	5th – 10th century AD

Table 4.1. Main periods and archaeological cultures found during the field survey.

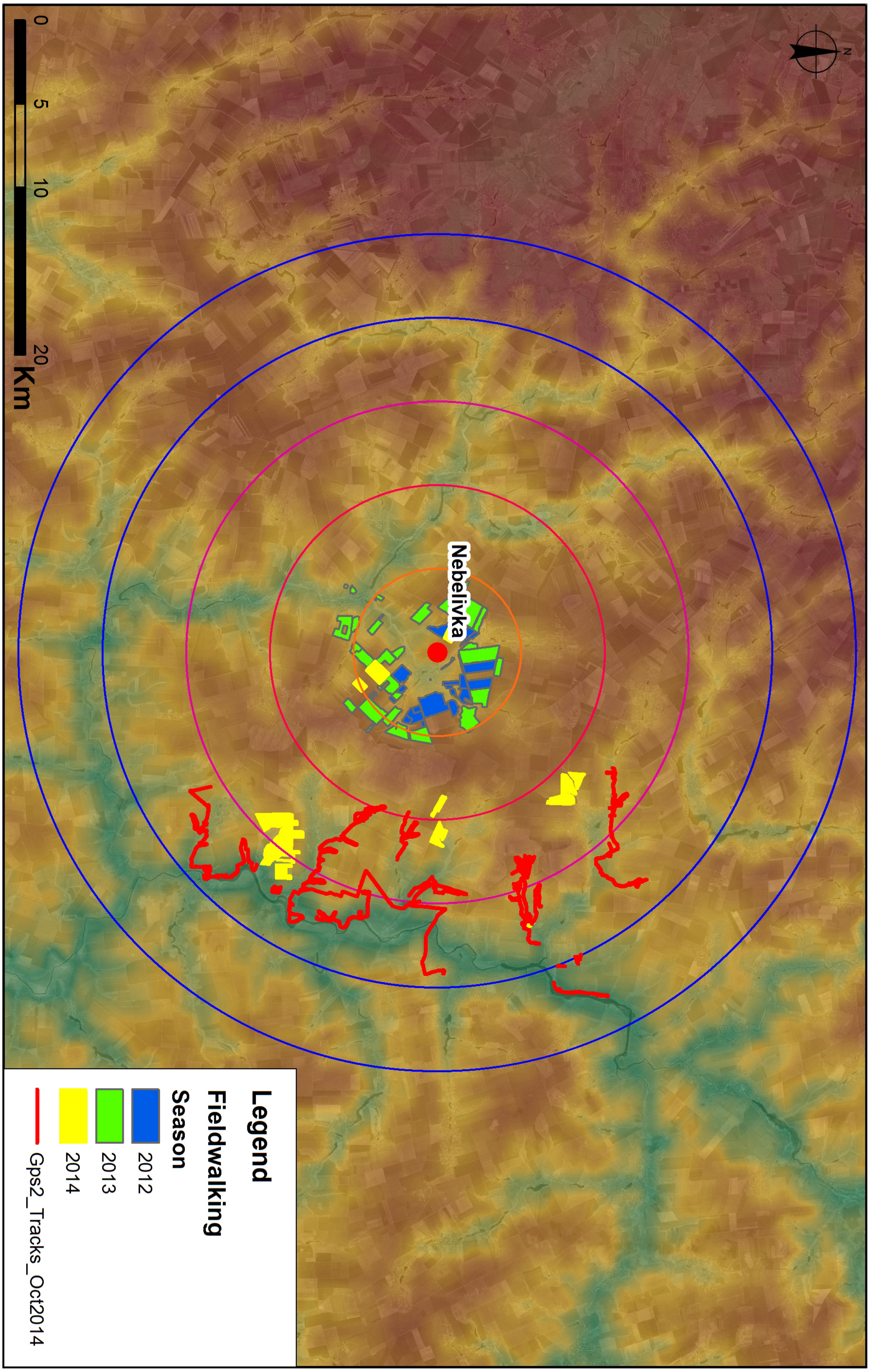


Fig. 4.21. Areas covered by the field survey in all three seasons (2012, 2013, 2014).

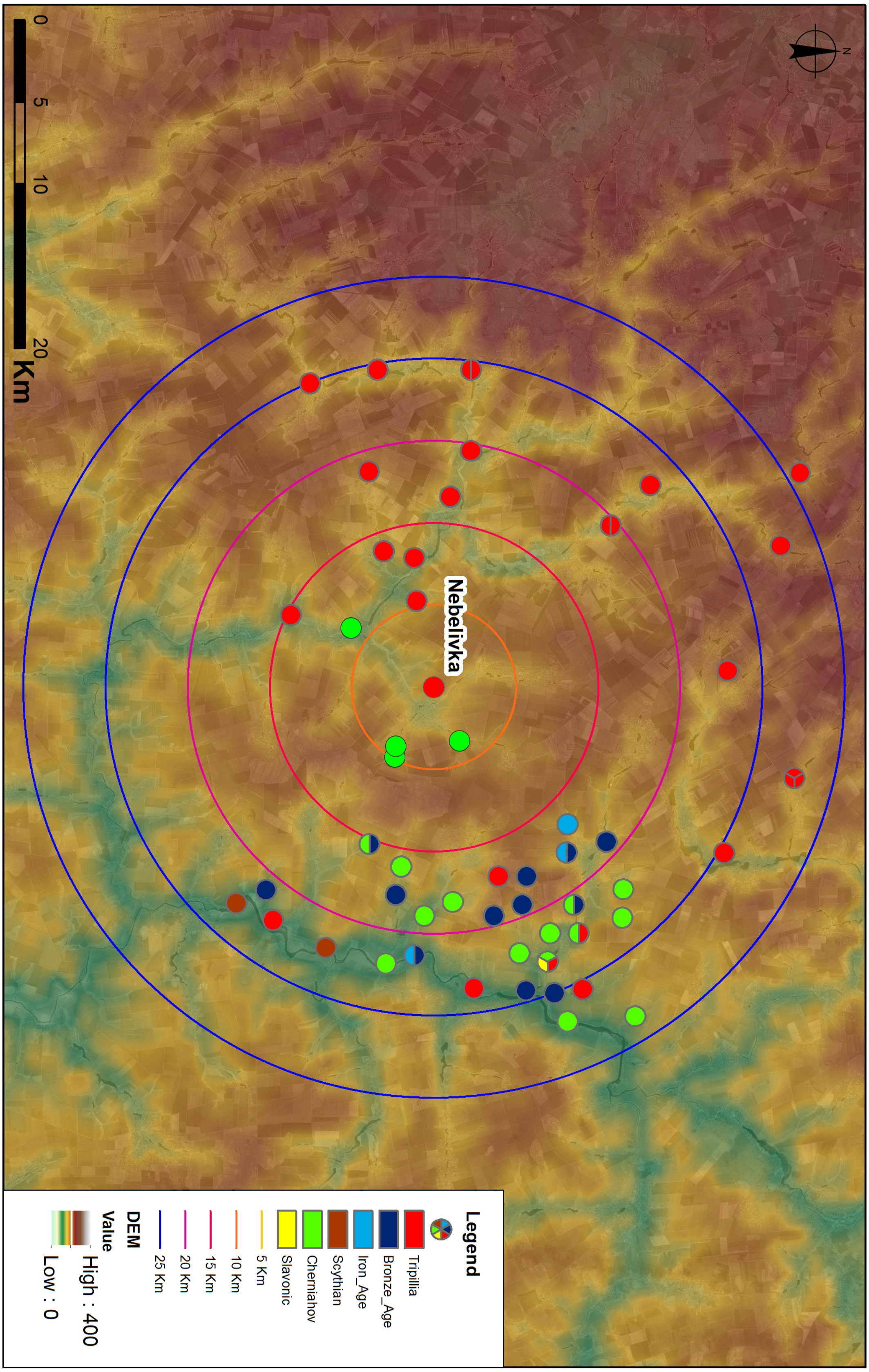


Fig. 4.22. Distribution map of sites recovered during the three season of field survey, plus the locations of known Trypillia sites in the Nebelivka macro-region.

We surveyed a total of 143.5 km along river courses covering an area of 574 ha during a short three-week season, finding 30 sites[19] of all time periods (two of which are Trypillia) (Fig. 4.21-4.22). Thus shifting from a site density of 0.001 per ha, in the first season, to 0.05 sites per ha. This result confirmed the settlement locational strategies being the same from the Copper Age to post-Medieval period. The investigated area included a transect leading from Nebelivka towards the mega-site of Volodymyrivka (Trypillia BII) situated on the southeast along the Synuha River (Fig. 4.23).

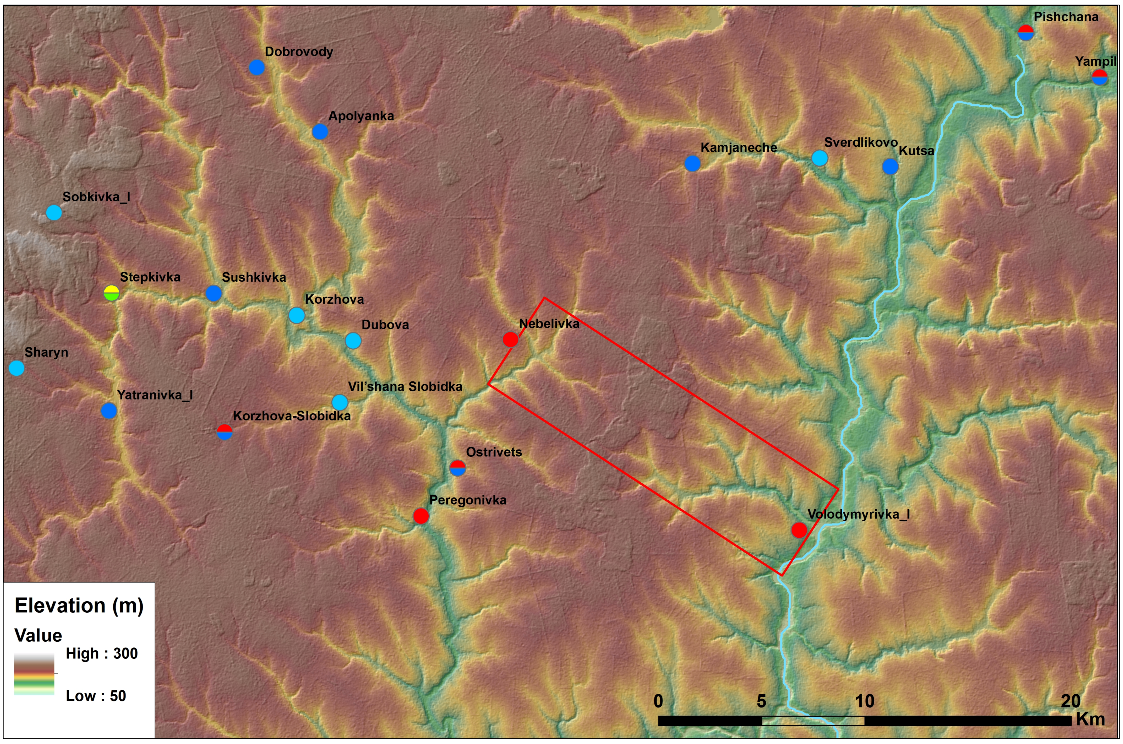


Fig. 4.23. Transect for planned field survey between Nebelivka and the coeval megasite of Volodymyrivka.

This choice was dictated by the question of looking for Trypillia settlements between two contemporary megasites in an archaeologically understudied area. Furthermore, the territory covering 25 km radius from Nebelivka has been chosen as wider hinterland to be investigated in terms of Trypillia settlement patterns, thus defining the megasite macro-region.[20] The macro-region comprises the counties (Ukrainian = oblast) of Cherkassy and Kirovograd and the border between the two crosscuts the study area more or less diagonally from northeast to southwest. This left the southeast quadrant of the macro-region totally within the Kirovograd county, which has never been properly investigated archaeologically. Therefore, the field survey focussed on the right bank of the river Synuha and all the right tributaries, both active and dried out. In this way the Southeast quadrant of the macro-region represents a

[19] See Appendix B for primary data.
[20] Decision driven mostly by cost and time reasons.

sample for both completing the knowledge on Trypillia presence and grasping insightful data on long-term settlement patterns trajectories (Fig. 4.21-22).

4.4.2.3 Site sampling strategy

Another goal of the field survey conducted along river courses has been to establish a method of sampling the single site, in order to understand its extension and gain some insights on the internal structure. Given that site scatters are clearly discernible from the background and they are mostly single phase (at least from the surface scatters), a sampling strategy intended to establish the shape, extent and internal organization of the site scatters has been adopted. Very few off-site materials have been found. The survey technique was a mix between extensive and intensive; thus meaning covering long river branches extensively and sampling each site scatter found intensively. The tight schedule and the limited manpower dictated the operative procedures. A first assessment of the scatter extent defined sampling intervals ranging from 20 metres, for small sites, to 80 metres, in case of 1.8 km long sites located along the lower riverbank. In this way it is still possible to compare the potsherd density between sites, by simply reducing the 20 m sampling to 40 m or 60 m or 80 m. We walked multiple transects across each scatter and picked up surface material within 3 metres radius samples until two consecutive samples were empty (Fig. 4.24). Samples were located using a hand-handle GPS device and the finds database - with information regarding sample number, quantity and chronological horizon, type of material, part of the vessel (for potsherds), dimensions (for building material like daub) and comments for special finds – merged with the points layer in GIS[21]. By plotting samples with material quantities and material types it was possible to define the edges of the scatter and therefore its shape, work out which were the core areas with a higher density of material distinguishing, in some cases, built up areas from open spaces, by comparing distribution and density of daub against potsherds. For some Early Medieval sites, by looking at the distribution of metal slags, it was also possible to locate production areas, usually at one end of the settlement (downstream). Despite the low percentage of multiphase settlements, in some cases it was possible to detect expansions, contractions and shifts of the settlements through time (like for the site of Krutenka (Fig. 4.25)).

[21] See Appendix B for GPS points and database of site sampling.

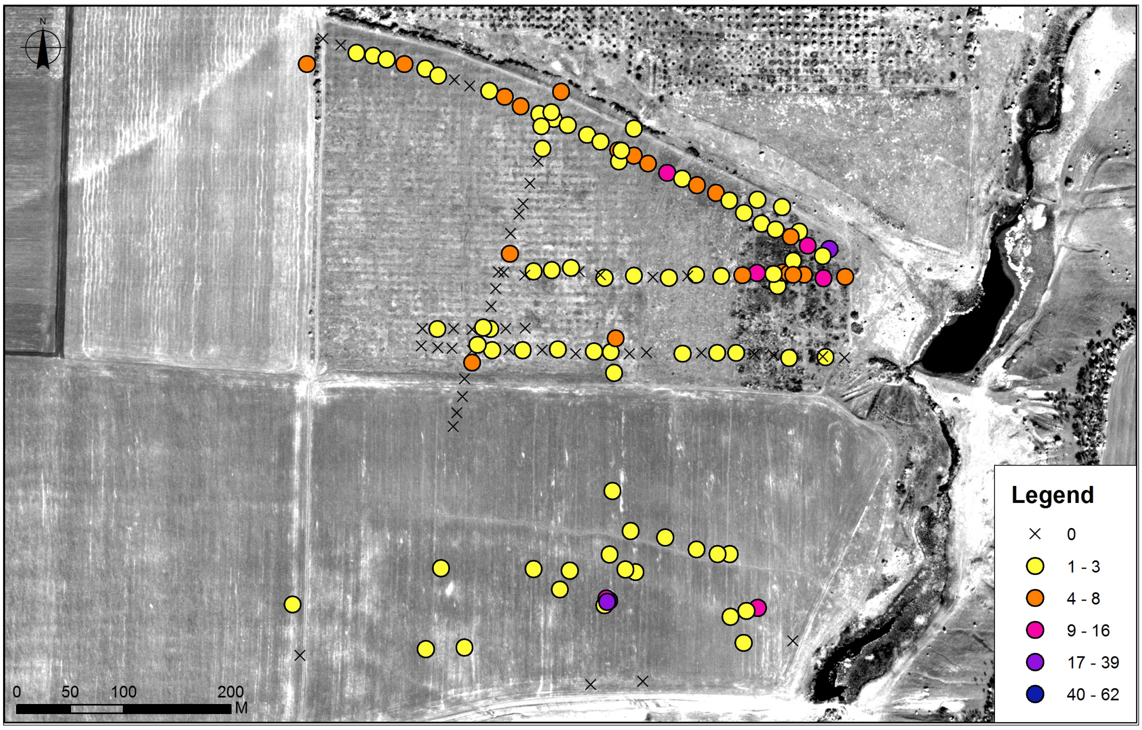


Fig. 4.24. Site sampling transects at the newly discovered Trypillia settlement of Kutsa (20 km northeast of Nebelivka), showing material counts.

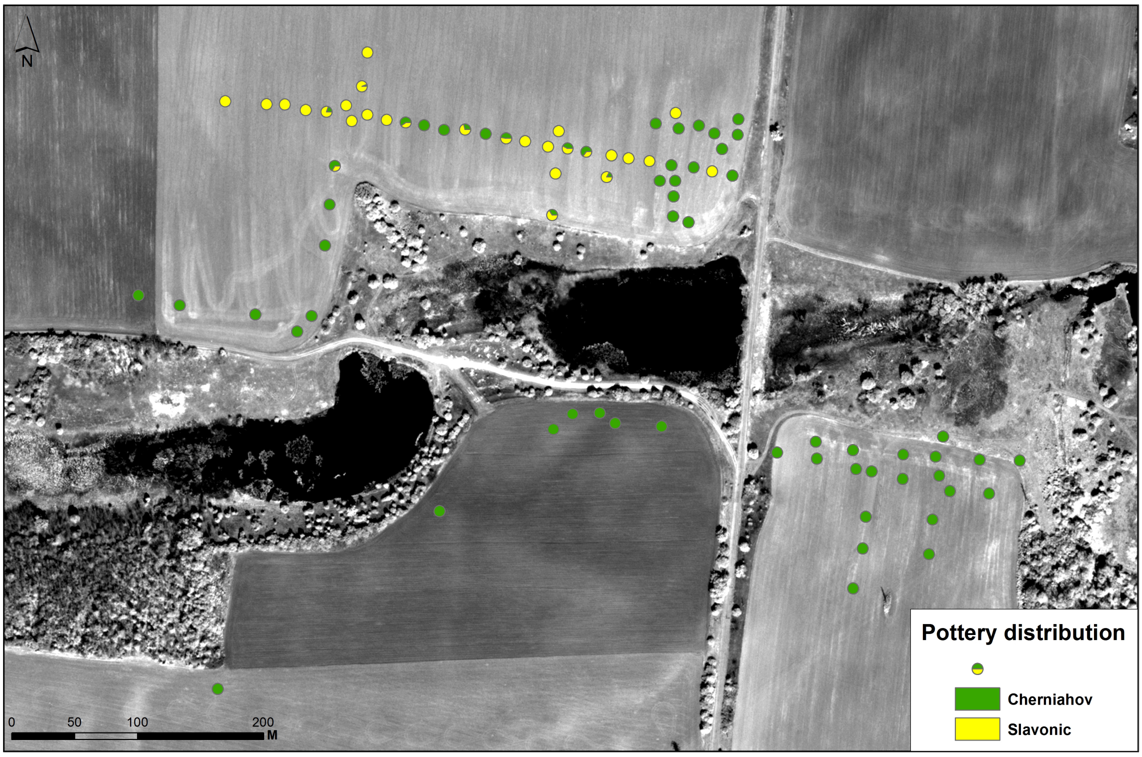


Fig. 4.25. Site sampling transects at the newly discovered site of Krutenka (10 km northeast of Nebelivka). Different colours represent different material from different time periods.

4.4.3 Size matters!

The second way field survey contributed to this research is to the assessment of information regarding site size derived from the literature. The major publication, edited by Videiko, contains all the Trypillia sites known in Ukraine compiled by gathering all available information; from unpublished amateur archaeological reports, to sporadic findings by local farmers, to scientific reports of excavated features (Videiko 2004). The sheer diversity of sources raised some issues about the reliability of the information reported. The broader discussion on how these data have been 'cleaned' will be treated in section 4.5, but for now the focus is on how I tried to assess the reliability of the information regarding site size – the latter is one of the most important types of evidence needed for my research. Not a single Trypillia settlement has ever been excavated in its entirety, mostly because of their massive extent. Therefore, the estimate of site size has always been derived from the dimensions of the surface scatter of material. Different techniques have been used to measure and to calculate the area of the halo. Generally, people have measured the two diagonals of the surface scatter and then calculated the extent by using the rectangle area formula. This has been criticised when scholars realized, from the aerial photographs (Shishkin 1973), that the shape of Trypillia settlements was oval rather than rectangular. Thereafter, archaeologists started calculating the sizes of surface scatters using the ellipse area formula, thus reducing previous estimations of site extent (Diachenko and Menotti 2012). Nevertheless, all these measurements, whether they were taken using the tape measure or the GPS, do not take into account the density of the intra-site features and the effect that the ploughing has on the dispersal of the surface material. The first issue has been addressed in the first season of the project in 2009, when the team walked on the megasite of Nebelivka and found a neat correspondence between surface material and sub-surface features (cross-validated with geomagnetic anomalies). The same results were obtained while surveying other Trypillia "not-mega" sites where the density of dwellings is lower and therefore each sub-surface structure shows up on the surface scatter quite neatly as a dense cluster of material. Even though we couldn't double-check the correspondence between surface and sub-surface features, we can argue that overall for Trypillia sites the surface material is an accurate proxy of the internal layout of the built-up area, based on the results of the gridded survey conducted at Nebelivka (Roe 2011) and the visual assessment on the ground[22]. This is probably due to the fact that the deep ploughing reaches the shallow eroded top of the archaeological horizon, which is quite rich in material and therefore the sheer amount of potsherds and daub that come to the surface is in neat contrast with the background soil. Therefore, since the micro halo of surface material of a single buried structure is generally very minimal, it is possible to work out a way of

[22] It was almost possible to see the rectangular shape of the structures from the surface scatter.

establishing the edge of the built-up area. First, the method has been tested on the site of Volodymyrivka, since the southwest limit of the site is quite clear from the satellite imagery and it has already been assessed that the anomalies visible on the imagery are in-situ features. By walking six parallel transects from the middle of the site towards the outside, using a 40 m spacing, we counted the amount of potsherds and daub in each sample (3 m radius) (Fig. 4.26).

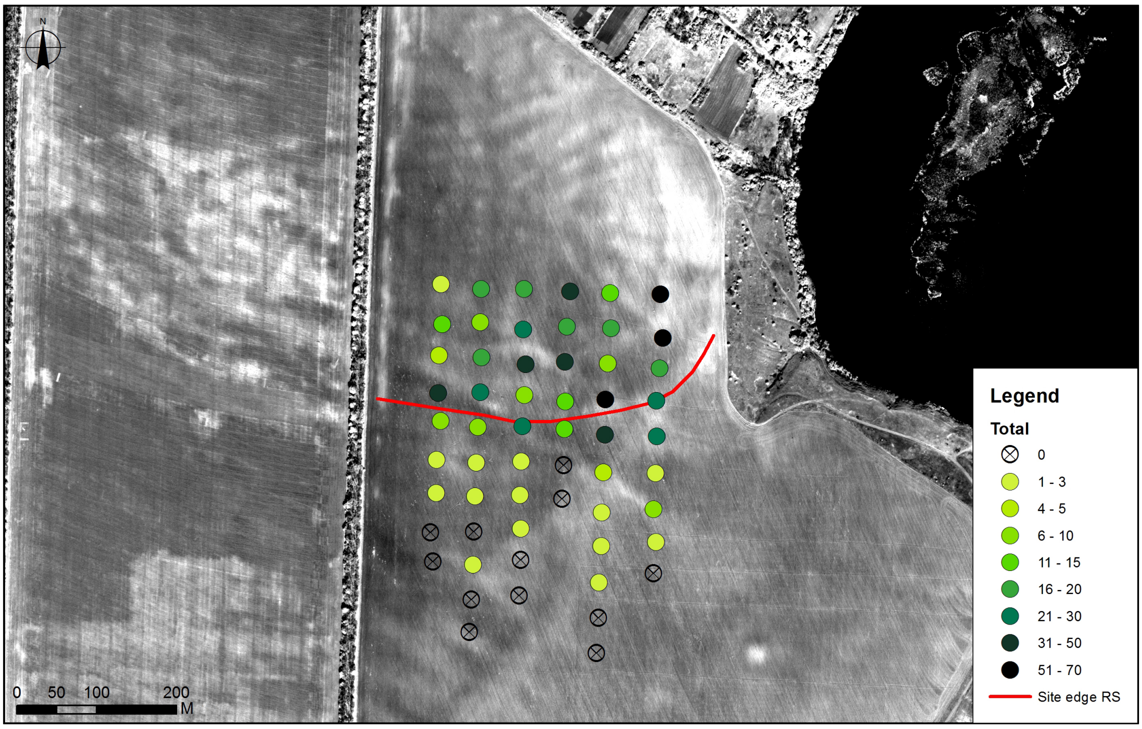


Fig. 4.26. Sampling transects on the Trypillia site of Volodymyrivka. The colour ramp indicates the quantity of both pottery and burnt daub collected at each sample. The red line shows the actual limit of the built-up area.

After plotting the results in a histogram chart, it is quite clear how while the middle of the site - where the six transects crossed alternatively, but not regularly, structures and open areas - produced an irregular trend in pot counts, the off-site part of each transect saw a drastic drop of material counts and an overall descending trend towards the off-site (Fig. 4.27). The interface between these two trends can be considered as the limit of the built-up area, because when beyond the site edge the amount of ploughed/dragged surface finds gradually decreases further away from the in-situ archaeology. This also means that the overall halo of surface material goes well beyond the site limits, thus leading to a general overestimation of the site size. After testing this method on other two Trypillia mega-sites (Nebelivka and Perehovnivka) with different geomorphological settings, it is clear that the overestimation is not consistent and not dependent only on the size of the built-up areas. Arguably, multiple factors can affect the spread of material on the surface and therefore it is hard to define a fixed percentage of overestimation. In conclusion, as much as the surface artefacts are a good proxy for the definition of a single dwelling and therefore the internal layout of the settlement, they are not reliable for the estimation of the built-up area as such, unless a systematic intensive sampling is conducted.

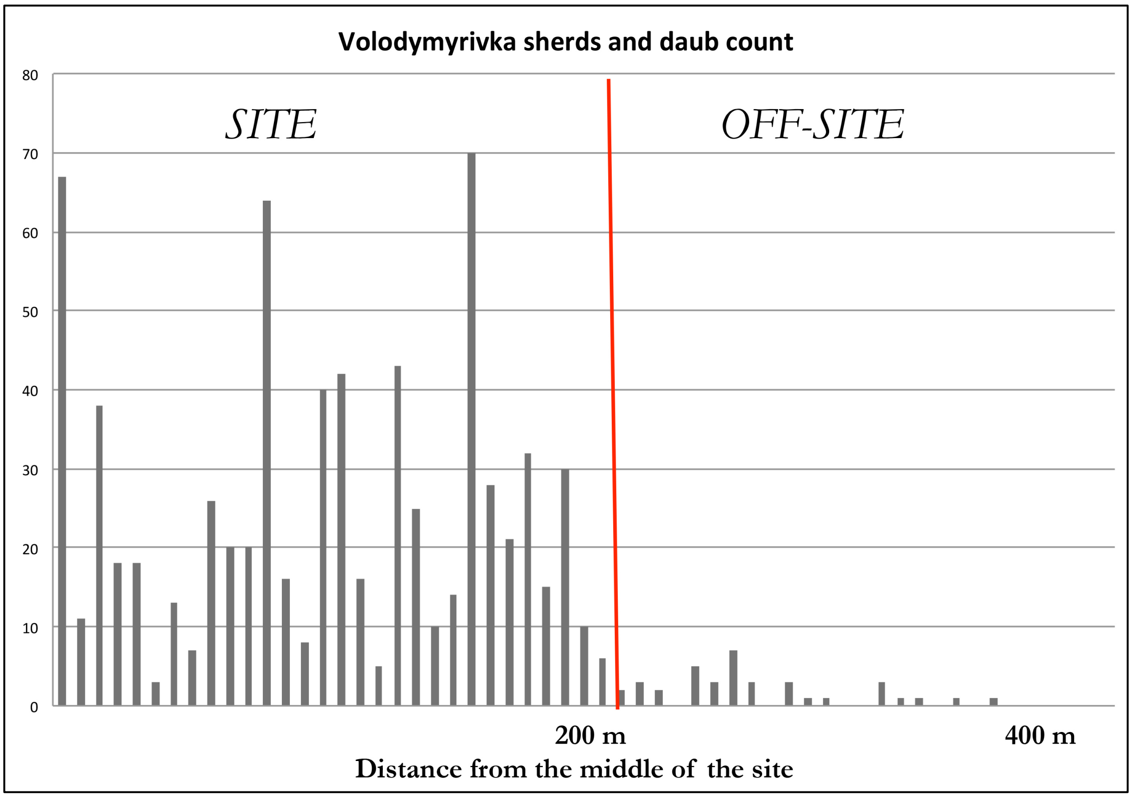


Fig. 4.27. Material counts of the 6 transects walked on the BII mega-site of Volodymyrivka.

4.4.4 From the space to the field: ground-truthing remote sensing interpretations.

The last contribution of the field survey activity to the research has to do with the cross-validation on the ground of the features detected and mapped from the satellite imagery.

When looking at a satellite image one can see all sorts of features but no one is completely sure of what one is looking at, therefore it is called an interpretation of the aerial image. The only secure way of defining the nature of a feature is to go and visit it on the ground. Then, next time one sees something alike on similar aerial image one will be more confident in asserting what they are looking at. If this rule is valid even for a well-known region, because the same feature can change the ways of manifesting itself on the image, depending on a number of factors discussed in section 4.3.2, it must be endorsed even more for a completely unknown territory. The latter was the case of the Ukrainian forest-steppe where Nebelivka is situated.

Therefore, after a first mapping and interpretation exercise, based on the knowledge of fundamental concepts of archaeological photo-interpretation and the experience of having worked with a range of different datasets, I needed to check on the ground the number of features detected on the satellite imagery. The ground-truthing exercise served for the assessment of the potential of the different available remote sensing datasets and to understand what has been mapped.

The choice of the best dataset has already been broadly discussed in section 4.3.2, therefore here I shall concentrate on the understanding of what is visible from space.

First of all, Trypillia sites are only visible in a very limited range of land use conditions, satellite sensors and soil moisture. The field-walking results showed that there are number of Trypillia mega and non-mega sites, which are not visible on the images, but very much detectable from surface collection. Nevertheless, Trypillia sites are quite unmistakable features to map by satellite imagery.

Moreover, there are a number of other features that can be seen on the imagery which allow for understanding the geomorphological characteristics and the general archaeological presence of a territory (see section 4.3.3 for detection of palaeochannels). Furthermore, some bright patches that look like archaeological sites on the images, and are situated along river courses – like the large majority of sites, turned out to be outcrops of the brighter clayish chernozem C horizon that is exposed by the effect of the constant water erosion.

At last, the great potential of remote sensing has been assessed for the recovery of burial mounds (=kurgans), characteristic archaeological features of the study area. After the first season and field survey it was clear how mounds of different diameters and heights (ranging from 0.3 m to 5 m) are highly visible on satellite imagery, both multispectral and panchromatic. This result yielded a database of nearly 800 kurgans mapped within the macro-region (Fig. 4.13). Of course, the limitation of remote sensing does not allow for an estimation of the real height of these features, but it helped enormously, during the second season, in targeting specific field visits aimed at the recording of even very subtle mounds, almost invisible from a ground perspective.

4.5 The Encyclopaedia of Trypillia Civilization

The core set of data included in this thesis derives from the publication of all the known Trypillia sites in the Ukraine (Videiko 2004). The so-called Trypillia Encyclopaedia is a collection of varied information from different sources such as published scientific papers and grey literature, from excavation reports to unsystematic and sporadic field visits. The collection of data has been built up since the 19th century when the first register and map of archaeological remains in Ukraine has been compiled. With the beginning of the 20th century an official register of archaeological monuments was collected in 1925 (V.U.A.K) and then updated until 1950, but never published. The first publication of Trypillia sites was in the mid of the 20th century with Tatiana Passek's book including 94 entries (Passek 1949; Childe 1951). A decade later Passek published an updated version which included some sites along the Dniestr in Moldova, a total of 125 Trypillia sites (Passek 1961).

A few years later, the first broad collection of archaeological sites in the country, including 960 Trypillia sites out of a total 7000 recorded, was published as Archaeological Monuments of Ukraine (Zbenovic, Kruts, Smaglij 1966). From the 1960s to the early 1990s a national programme of recording archaeological sites developed a standard protocol of data collection by preparing a document for each site (Passport) where basic information regarding the type of site (settlement, burial mound, surface scatter), period and dimensions were registered. During this period of investigation many previously unknown Trypillia sites were found. Counties like Vinnitsa, Cherkassy and Kirovograd remained poorly investigated. In 1971, the first map of 171 Trypillia sites was published within the Archaeology of the Soviet Republic of Ukraine volume. Since the fall of the Berlin Wall and the end of the Soviet era, the national programme of archaeological investigations has been decentralized and each county (oblast) developed its own plan for site recording and mapping. In 1995, a series of regional maps were published for the counties of Chervinits, Vinnitsa, Ternopil, Khmelnits and Odessa. This included the plotting of site locations on a map as well as recording other basic information. From this moment the development of registers of archaeological monuments has been in the charge of each county as well as centrally monitored by the Institute of Archaeology in Kiev. The non-systematic and decentralized way of managing the archaeological heritage has led to a level on uncertainty regarding the number of known Trypillia sites, so that some archaeologists (e.g. Videiko) have mentioned that these are around 1500, whereas others (e.g. Ryzhov) are more optimistic, with around 5000 Trypillia sites (Videiko 2004, 564).

Finally, in 2004, a comprehensive collection of all the information regarding known Trypillia evidence has been published as an edited volume called the Encyclopaedia of Trypillia Civilization (Videiko 2004). The contents of the encyclopaedia span from scientific publications to archive material, from unpublished research and excavation reports to sporadic amateur notes. All the information has been taken from all the abovementioned sources and updated with new discoveries from 19 counties (oblasts), for a total of 2042 Trypillia entries, although some Ukrainian archaeologists claim that they are up to 4400 (Videiko 2004, 564). Unfortunately, the information collected since the beginning of the 20th century has not been assessed nor evaluated with field visits or excavations but rather taken as granted and reported while the main focus has been devoted to finding more (and possibly bigger!) sites. Meanwhile, as field methodologies and theories advanced and developed, the information collected since the 19th century has not been double-checked or updated with improved recording procedures. Therefore, the Encyclopaedia represents a massive amount of information compiled using a varied range of methods and field procedures that produced an uneven and inconsistent dataset. This has urged an overall assessment of the data in order to select the most reliable information and exclude the rest from the analysis and interpretation.

4.5.1 Encyclopaedia legacy data

The encyclopaedia is organized in alphabetical order by county, by municipality and by nearest village. If there is more than one site around the same village the name is followed by Roman numerals or Arabic numbers often mixing the two systems and not following a consecutive order; therefore, the end number is not indicative of how many Trypillia sites there are in the vicinity of a specific village. Sometimes, if there are many archaeological findings around a single village, some sites are named after the closest river, using a very local name or the oldest name found in a historical map. The ID of each entry is reset for every county and therefore there is no unique numbering system across the whole database. Overall, there is no effort to make the data taken from different sources look uniform in a consistent arrangement.

The information reported consists of: 1) a description of the site location, 2) a brief history of site investigations, 3) an estimation of the extent of the site, 4) the chronological horizon of the material found on site.

There are a number of issues regarding the way information has been recorded in the encyclopaedia and these are the starting points of the data assessment and data cleaning processes. But before that we shall describe the contents of the encyclopaedia in more detail.

4.5.1.1 Site locations

The majority of site locations are defined using topographical and hydrological references, such as rivers, river junctions, fields, woods or hilltops. All the sites are located in the vicinity of a village or town and therefore, often named after the nearest modern settlement. The tendency is to use very local names for natural features such as for very small river courses and woods, as they are specific of that one feature and not mistakable with surrounding streams or woodlands. Sometimes archaeologists also used river names found in old maps (19th century maps) to define the location of archaeological sites. In more recent excavations and geophysical prospection reports it is sometimes possible to find GPS coordinates of the site. Nonetheless, the way archaeologists describe site location hasn't changed much until now.

4.5.1.2 History of investigations

For every site a list of investigations of all sorts is provided with relative references to the literature stored in the central archive in Kiev. Typically, the first discovery of the site is reported along with a mention to every following intervention in the field. Sometimes sites are "found" multiple times over a period of 20 – 30 years. The names of the archaeologists who investigated the site are provided for the major settlements along with dissimilar data resulting from different excavations or geophysical surveys. The type of investigations conducted is also reported.

4.5.1.3 Site chronology

The two main pieces of archaeological information reported are site chronologies and site sizes.
The chronological reference is the relative chronology derived from pottery typology seriation that divides up the Trypillia period in 6 major phases (A, BI, BI/BII, BII, CI, CII) (Table 4.2) (Rassamakin 2011, 646). This phasing system is used throughout the Encyclopaedia, although for sites found in earlier times (before the 1970s) there are other, former, chronological subdivisions (such as Early, Middle and Late Trypillia). Unfortunately, only about 500 sites, out of 2,048 recorded, report information regarding the chronological phasing. Some of them have only been attributed to a general phase (9 to phase B and 16 to phase C) without further subdivision. Furthermore, some sites have been assigned to two non-consecutive phases but it is not clear whether this means a long-term continuity of occupation or if that includes periods of site abandonment. Finally, for 132 sites a typological ceramic group is

reported, providing for a more fine-grained chronological sequence (mostly for the Southern Bug- Dnieper interfluve).

Archaeological Phase	Absolute chronology cal BC
Trypillia A	5000/5100 (?) – 4700/4600
Trypillia BI	4700/4600 – 4400/4300
Trypillia BI/BII	4400/4300 – 4200/4100
Trypillia BII	4200/4100 – 3900
Trypillia CI	3900 – 3450/3350
Trypillia CII	3450/3350 – 3000/2900 (?)

Table 4.2. Table showing absolute chronology derived by pottery seriation, Trypillia group (Rassamakin and Menotti 2011).

4.5.1.4 Site size

The most important piece of information reported in the Encyclopaedia is site size. For 240 out of the 2,048 sites an estimate of the site extent is provided either in hectares or as a pair of linear measurements in metres. Unfortunately, there is no explanation of how these measurements were taken on the ground and how the estimates have been derived. Nonetheless, thanks to the old-fashioned tradition of field methods, still in use nowadays, we know that archaeologists have been estimating site sizes by calculating the extent of surface material distributions after measuring the two diagonals of the scatter. For some sites the two measurements were reported (in metres), for others the area of the scatter has been calculated using the rectangle area formula (in hectares) (Diachenko 2012, 117).
These are the information that have been reported over more than a century of Trypillia studies; the next section evaluates how we can use these data.

4.5.2 Assessing Ukrainian legacy data reliability

The information contained in the Encyclopaedia has never been assessed or double-checked, therefore inaccuracies, derived from the adoption of old and, by now generally obsolete, field methods and theories, have been transmitted on to the final version of the publication. The compilation of metadata regarding how data have been collected in the field is lacking for almost all the entries. It is therefore, necessary to evaluate the reliability of the information by trying to understand how people recorded sites in the field and elaborated reports. The fact that field methods and theories have not changed so much in Ukrainian archaeology, possibly as part of the Soviet legacy, has turned out to be quite advantageous in gauging the archaeologists' field methods.

4.5.2.1 Assessing site locations

A number of issues have arisen while scanning the various descriptions of site locations throughout the Encyclopaedia trying to locate sites on the map. First of all, there is not a single GPS coordinate reported in the publication and all the locations are described using natural features as references. Secondly, the descriptions used topographical and hydrological references that are not reported on any available map, but rather refer to terms adopted locally. Thirdly, it occurs sometimes that exactly the same description is given for more than one site in the surroundings of the same village or town. Moreover, in some cases more than one site shares the whole description in the same municipality, therefore it looks like it could be the same site recorded multiple times (like in the case of the village of Viktoriv in Ivano-Frankivsk oblast, Halytskyi region, that counts 20 Trypillia sites of 2 or 3 ha, in the same location outside the modern settlement).

Nevertheless, we[23] tried to locate sites using Google Earth and Google Maps to find every village or town, discarding sites that are described in the exact same way around the same village. For every site each available satellite image has been looked at in order to check whether the site was showing up as a cropmark or a soilmark and then defined a level of certainty (from 0 to 1) for the location assigned (Fig. 4.28).

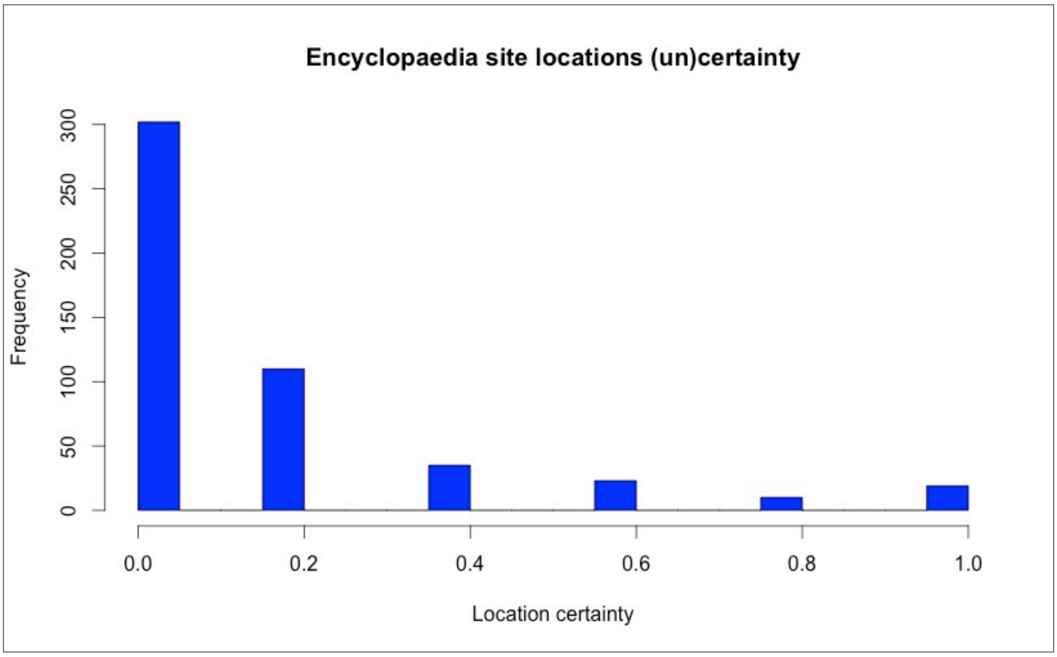


Fig. 4.28. Barplot showing the overall certainty of site location for the Trypillia database.

[23] Thanks are due to Bisserka Gaydarska who assisted the translation and interpretation from Ukrainian.

Moreover, for sites that are visible on the satellite imagery a level of visibility (from 0 to 1) has been attributed and that indicates also the level of confidence for the location assigned. The knowledge of the locational strategies of Trypillians (at river junctions, not in the first river terrace, not too high in the more elevated areas, etc...) derived from the field survey data (see section 4.4.2), helped in placing the sites in the most probable spot.

4.5.2.2 Assessing site sizes

The most difficult information to assess is the estimation of site extent reported in the publication. There are a number of issues related to this topic and it is vital to address them as this piece of evidence (which is also the only one for the majority of the sites) stands at the base of most of the analysis performed in this research. Therefore, it is fundamental to determine the reliability of this information.

The way archaeologists have been measuring and recording site extent has not changed much over time. Although the tools have become increasingly more accurate, only a few of the old measurements have been reassessed and reported in the Encyclopaedia. The majority of site dimensions, reported in the final publication, have been transmitted as they were first recorded.

Scholars realized that these measurements where based on the area formula of the rectangle but actually Trypillia sites have an oval shape (Passek 1949; Markevich 1981; Chernysh 1982; Diachenko 2010). Nonetheless, we had to wait until Diachenko who, in the last decade, started using the ellipse area formula to estimate the size extent of settlements (Diachenko and Menotti 2012), to see a critical use of the information reported in the Encyclopaedia. The question that not even Diachenko posed, though, is whether the spread of material on the surface is actually representative of the site or settlement extent. Although this is an old issue in the Mediterranean survey tradition, nobody within the research on Trypillia sites had addressed it as yet. Furthermore, how can we measure site extent?

One of the most important methodological innovations of this research was to establish a method to accurately estimate the extent of the built-up area of a Trypillia settlement from the ground (see section 4.4.3). The method shows how site sizes derived from measuring the extent of surface material scatter do not represent the extent of the sub-surface archaeology. The spread of material on the ground surface goes well beyond the limits of the built-up area, thus returning a general overestimation of sites' extents. Moreover, the fact that site anomalies visible on the satellite imagery correspond to in situ features, rather than halos of surface material (see section 4.3.3), helped in quantifying the degree of error in site sizes estimation. Unfortunately, only 15 out of 2,048 sites recorded are visible on the imagery, but this, nevertheless, allows for calculation of their extents in comparison to the values reported in the Encyclopaedia (Fig. 4.29).

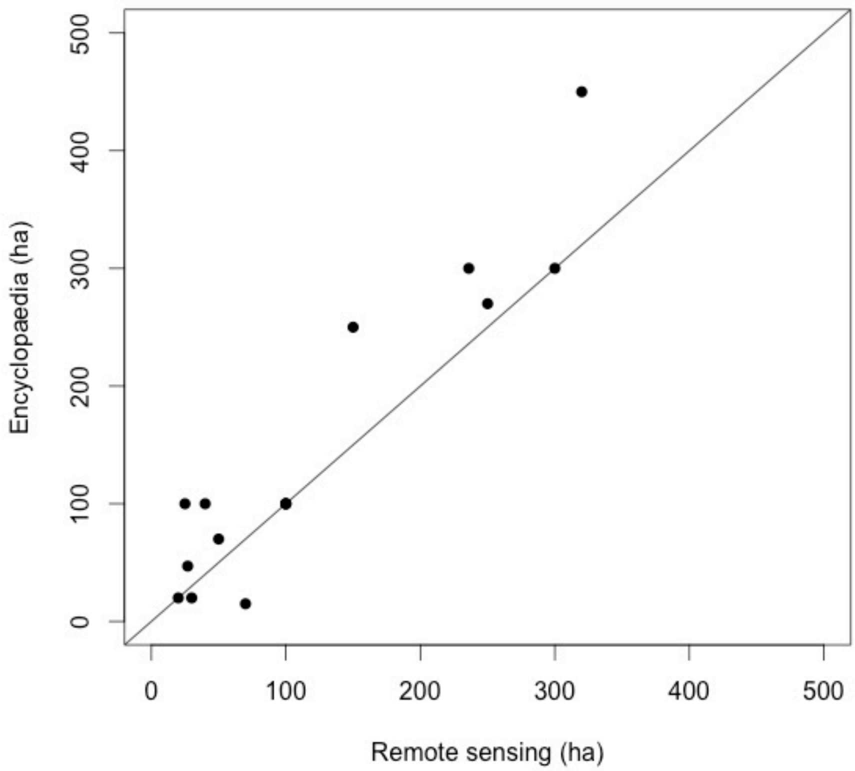


Fig. 4.29. Scatterplot of site sizes reported in the Encyclopaedia against the values measured from the satellite imagery.

As shown in Fig. 4.29, 60% of sites' areas are overestimated, in an inconsistent way. There is no linear correlation between the degree of overestimation and the size of the settlement. There are many factors that affect the measurement of the surface scatter extension and consequently the estimate of site size: 1) the topographical conditions of site locations, 2) the season in which the survey is conducted, 3) the position of the edges of the built up area against field boundaries (as in the case of Nebelivka on the south side, where the outer circuit of dwellings lay in the middle of a field, produced a much bigger halo of surface material than the west side where the site edge corresponds to the field boundary), 4) whether, like in the case of Perehonivka, the site limit corresponds to a palaeo-hydrological feature that stemmed the spread of material on the surface, and 5) standard human errors while recording.

Owing to the variety of factors that affect the estimations of site sizes from field measurements, it was impossible to define any constant error or consistent correlation with the actual site areas.

This prevented me from possibly correcting or adjusting the site sizes reported in the encyclopaedia, but a selection of the data defined as “usable” within this research project has been done as follows. However, a good example of how this method would contribute to the assessment of the Encyclopaedia contents is represented by the Trypillia site of Kutsa (20 km northeast of Nebelivka) that was newly discovered during the last season of field survey. The site has been sampled with multiple transect (20 m spacing) and the results plotted on a map (Fig. 4.30).

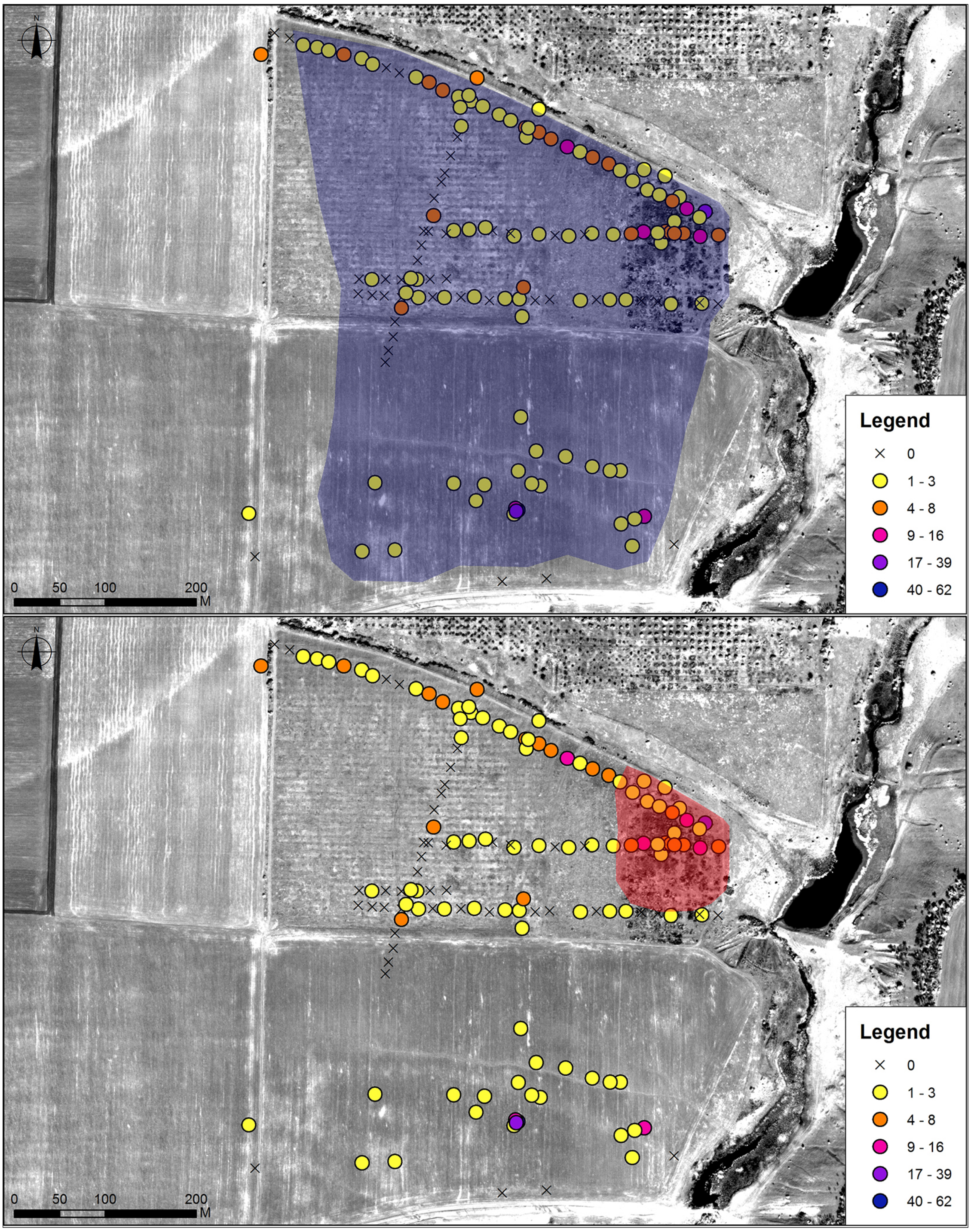


Fig. 4.30. Comparisons of the two size estimates of the same site of Kutsa.

Fig. 4.30 shows how the estimated size that would be reported in the Encyclopaedia is of 20 ha (blue halo), whereas the one derived by the method developed by this research would be of 1 ha (red halo). This also stresses the remarkable difference that a re-survey of every Trypillia sites reported in the Encyclopaedia would make.

4.6 Data cleaning

After the assessment of data quality contained in the Encyclopaedia, the information that was indeed usable for this research has been defined.

The more challenging operation was to locate the sites on the map by following the descriptions reported, and using Google Earth to identify the natural features used as reference points. First, it was essential to decide which sites were "worth" plotting, on the basis of which entries contained the most reliable information of site chronologies (Trypillia phases) and site sizes. The problem of not having any metadata about how this information were collected in the field made it a difficult decision to take and even harder to assign any sort of confidence level. At first all the sites for which information regarding phase and area was provided were considered. A total number of 240 sites have been plotted on Google Earth, based on the locational descriptions found in the encyclopaedia; and for each entry a level of confidence of the proposed location has been indicated. The number of sites per phase was not enough (for every phase) to perform the most common geostatistical analysis that require a minimum of 30 entities in order to be run; hence the decision of plotting more sites and including them in the final database.

The solution was to include sites for which information about phase was provided in the Encyclopaedia. Starting from the assumption that if chronological information was given it meant that a minimum number of dwellings must have yielded enough material to include diagnostic potsherds. We therefore assigned a default area size of 0.3 ha, which corresponds to the minimum size of the already mapped sites, to 259 more sites. The inclusion of these extra entries allowed for a more solid and reliable diachronic geostatistical analysis of settlement patterns.

An assessment was needed to ensure that the addition of extra sites with a default value would have not affected the analysis. The main issue that this might have caused was the alteration of site size variability across the five Trypillia phases, therefore an evaluation of the influence of these extra 259 sites had on the overall data pattern has been conducted.

One of the most commonly used indexes to measure inequality of whatever kind of variable is the Gini coefficient, which calculates the statistical dispersion of a specific value (Gini 1912). The coefficient can also be expressed as half of the relative mean absolute difference of all pairs of values (Fig. 4.31).

$$G = \frac{\sum_i \sum_j |x_i - x_j|}{2 \sum_i \sum_j x_i}$$

Fig. 4.31. The Gini coefficient formula.

It is usually applied in modern economics to estimate social inequality, by using income values as a proxy and seeing how wealth is distributed. If applied to site sizes it is possible to measure the variability of that value in a given sample and compare five different samples. This has been used to assess how much the value variability was affected by the addition of 259 extra sites.
If we compare the diachronic trends of the five Gini coefficients before and after the inclusion of extra sites it is noticeable that they are relatively similar. There is an upward shift of the trend line as the number of entries increased, but in fact the pattern is consistent (Fig. 4.32).

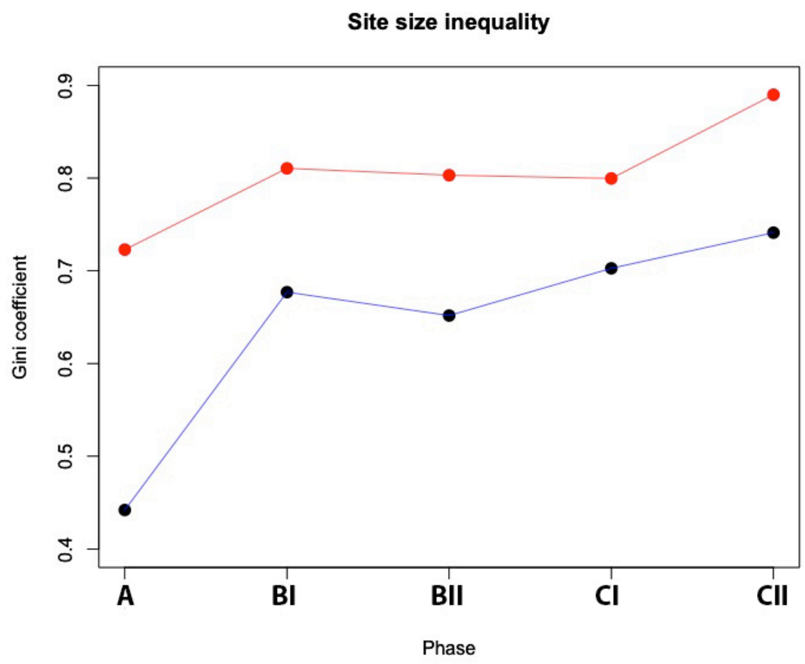


Fig. 4.32. Plot showing the Gini coefficient calculated for the five samples, before (blue) and after (red) the inclusion of further sites from the Encycloaedia.

This means that the addition of more sites with equal area sizes did not affect the variability of this value throughout the five chronological phases. Therefore, any spatial statistics that will involve the analysis of site size variability during the Trypillia period will not be affected. This led to the final plotting of Trypillia sites in Google Earth, for a total sum of 499 settlements then imported into a bespoke geodatabase. In Fig. 4.33 the effect of the data cleaning process on the count of sites per county is shown.

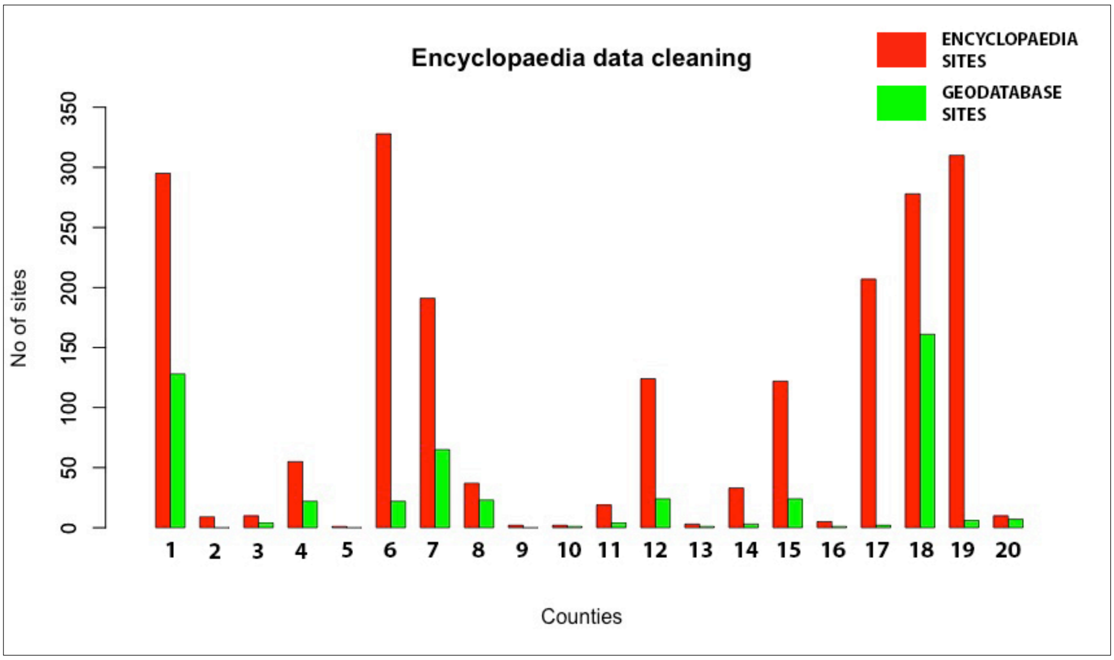


Fig. 4.33. Barplot showing the effects that the data cleaning on the number of sites per county. The counties are: (1) Vinnitsa, (2) Volynska, (3) Dnipropetrovska, (4) Zhytomyrska, (5) Zaporizhia, (6) Ivano-Frankivsk, (7) Kiev, (8) Kirovogradska, (9) Crimea, (10) Lviv, (11) Mykolaivska, (12) Odessa, (13) Poltavska, (14) Rivenska, (15) Ternopilska, (16) Khersonska, (17) Khemlnytska, (18) Cherkaska, (19) Chernivetska, (20) Chernihivska.

The number of sites per county diverges considerably across the Ukraine, and the percentage of entries that survived the data cleaning process varies independently from it, as shown in Fig. 4.33 and 4.35. It appears that in some cases a county with 2 reported Trypillia sites kept more than 50% of the entries after the data cleaning which means only one site (L'viv), whereas in other cases a county with 207 entries remains with only 2 containing reliable information (Khemlnytska). Therefore, in order to estimate the optimum dataset where the number of sites is more reliable, a combination of the two maps into a single raster (multiplying the raster showing the percentage of "survived" sites times the raster containing the number of sites left after the data cleaning) showed the counties containing more data and more reliable information (Fig. 4.36). Cherkassy and Vinnitsa are the counties with the best combination of number of sites and data quality, followed by Kiev and Kirovograd. All four represent the core area of Trypillia sites distribution.

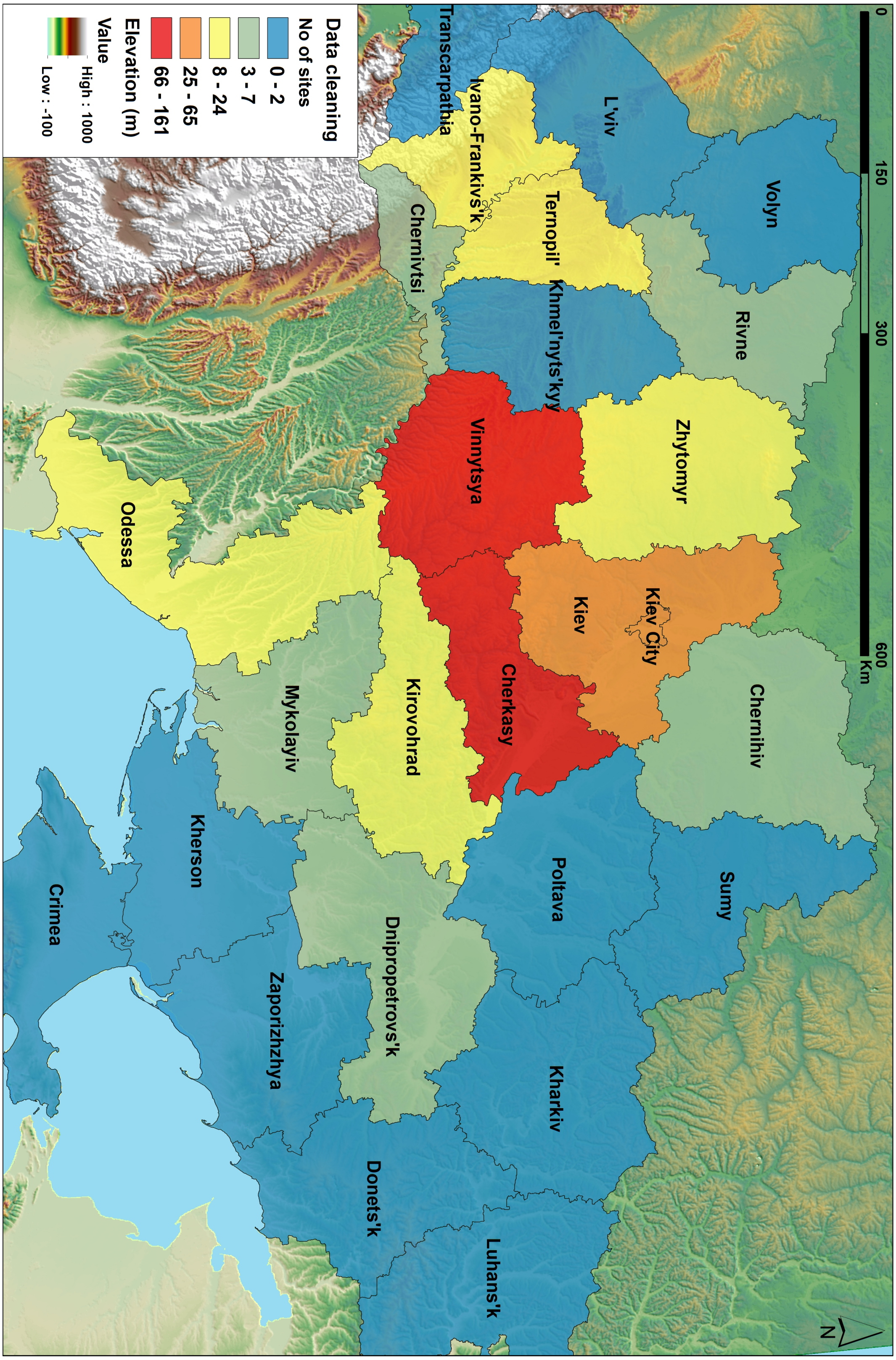


Fig. 4.34. Number of sites per County after data cleaning.

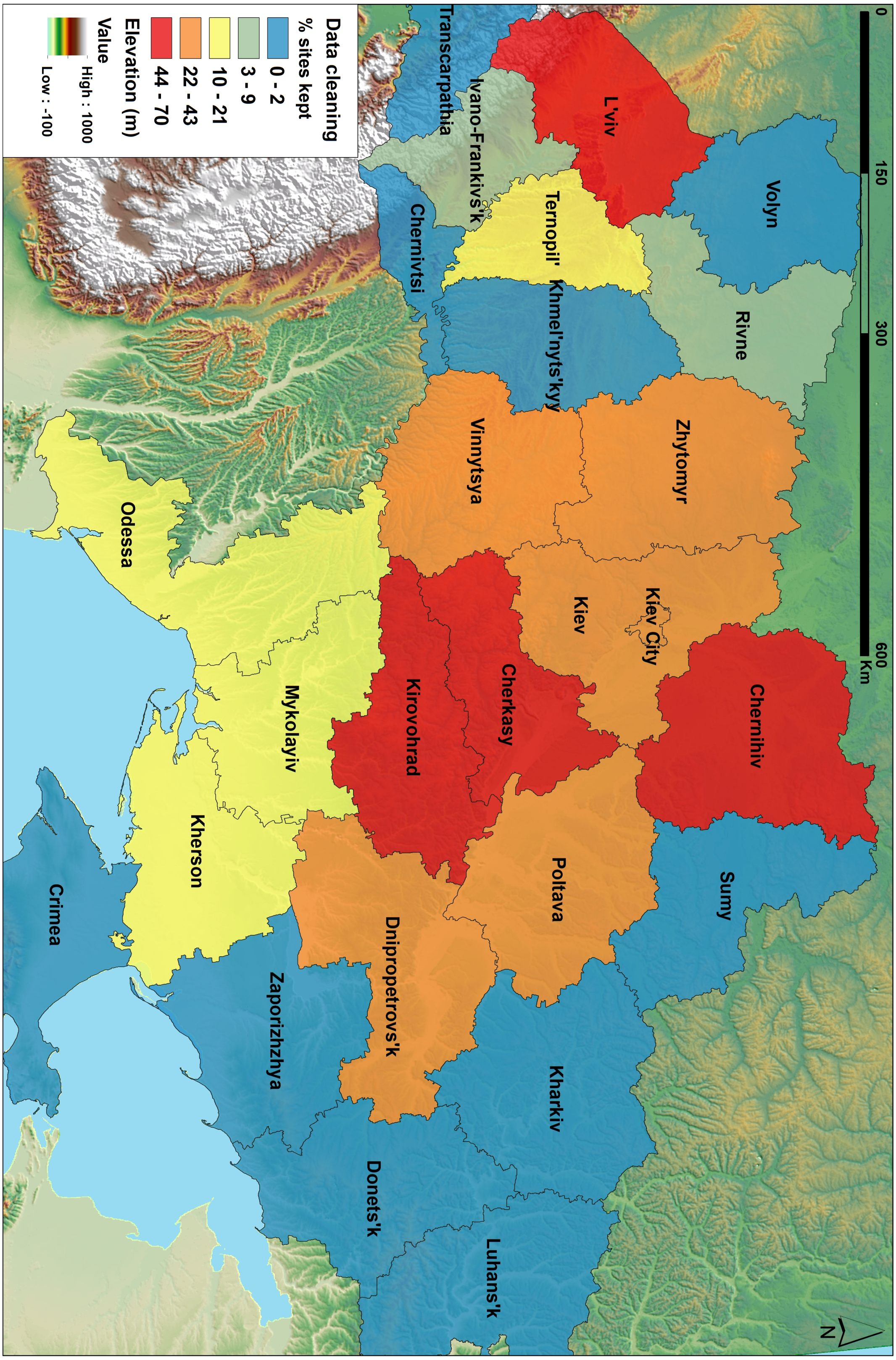


Fig. 4.35. Percentage of sites that "survived" the data cleaning process, per County.

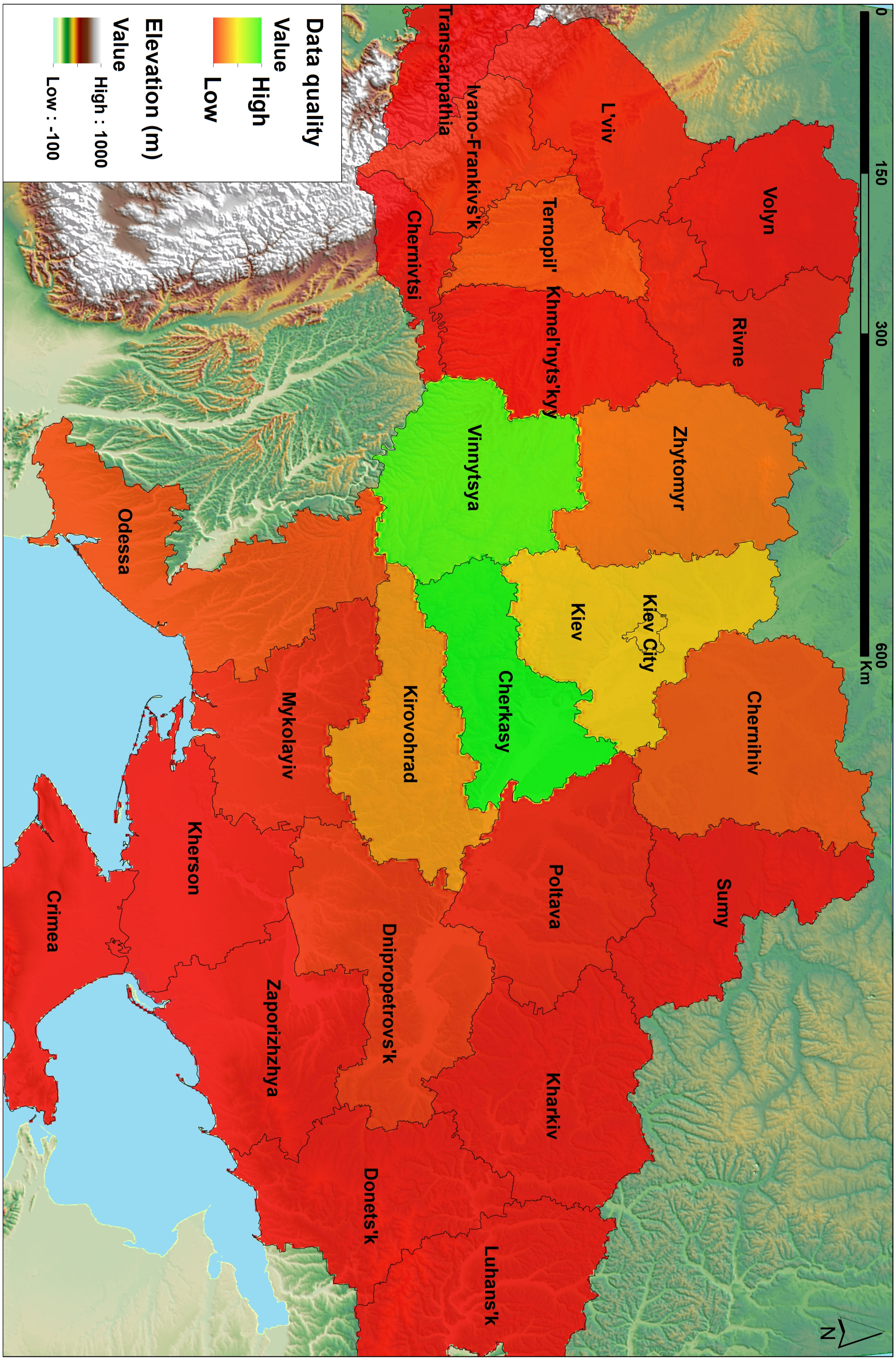


Fig. 4.36. Counties with the best combination of number of sites and data quality.

Overall, the assessment of published data has clarified the reliability of the information and allowed the creation of the new database of Trypillia sites that has served as a basis for the analysis of this research. It is the first time that the Encyclopaedia has been tackled and assessed as a whole; usually scholars have concentrated on using datasets of well-known megasites and never tackled the whole record of information. Unfortunately, it is hard to get access to the archival material where the original reports and publication are stored, and even then it would be hard to extract the data that are usable. Nevertheless, in order to better comprehend the formation processes, the nature, and the function of Trypillia mega-sites it is fundamental to try and use the widest set of reliable data, even with all the informative limitations that this carries.
In the next section the structure of the database will be illustrated.

4.7 Encyclopaedia geodatabase

Having plotted the Trypillia sites, selected from the Encyclopaedia, using Google Earth, the data have been imported into a GIS platform within a bespoke geodatabase.
As already developed for the storage of remotely sensed features, the ESRI ArcGIS data model has been adopted for recording published data (along with the only newly discovered Trypillia site: Kutsa) into the same spatial framework. There are many ways to spatially represent an archaeological object, and probably the best geometry would be a polygon as it embodies at least two of the three dimensions. Unfortunately, if the exact location and exact shape of an archaeological site are unknown there are more problems than advantages in trying to replicate on a map a completely (or almost) invented shape and extent of it. Since this is the case for data coming from the encyclopaedia, a simple point-shaped has been chosen as the physical representation of each settlement reported to the map. Only for those 15 sites (see section 4.5.2.2) that are visible on satellite imagery was a polygonal graphical representation attempted.

FIELD	DESCRIPTION
ID	Unique ID identification number.
Name	Name of the nearest village or main watercourse (as it appears in the Encyclopaedia).
Oblast	Name of the county where the site is located.
Region	Name of the municipality where the site is located.
Phase	Trypillia phase attributed to the site (see table 4.1 for Trypillia relative chronology).
Area (ha)	Site area as reported in the encyclopaedia for the majority of the sites and corrected where possible.
A	Boolean value of presence/absence.
BI	Boolean value of presence/absence.
BII	Boolean value of presence/absence.
CI	Boolean value of presence/absence.
CII	Boolean value of presence/absence.
Remote_sensing	Level of certainty for site visibility on satellite imagery (from 0 to 1).
Stage_code	A numerical value for the assigned Trypillia phase.
Location_certainty	Level of certainty for the location assigned to the point (from 0 to 1).
Elevation	Elevation of the point derived from the SRTM data (30m) in metres.
Notes	Notes on the pottery group assigned to the site (if present) and other general notes.
Annotations	Annotation on where the area value has been derived from fro that specific site.

Table 4.3. List of all the fields of the attribute table of the Trypillia geodatabase.

Table 4.3 shows how the information, derived from the Encyclopaedia, has been reported, for each point (representing a site), into the GIS database.

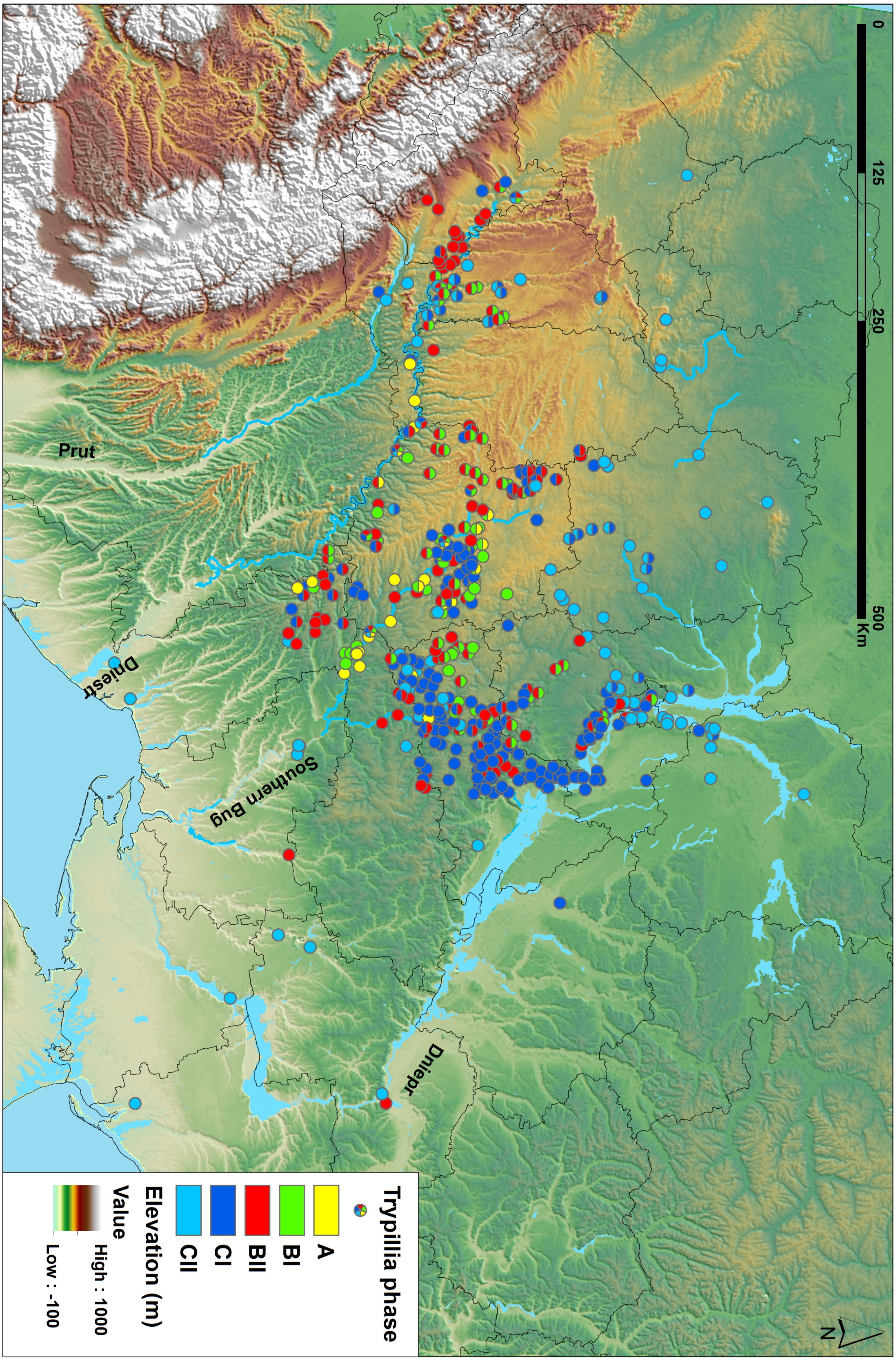


Fig. 4.37. Overall distribution of the total of Trypillia sites included in the final geodatabase.

As shown in Fig. 4.37 the overall scatter of the 499 sites (the sum of the initial 240 plus the extra 259 sites) included in the final geodatabase[24] highlights the uneven spread of those in the landscape. A series of histograms displaying site size frequencies for the five phases are shown below (Fig 4.38). It is clear that the distribution is correlated to the different levels of investigation of the 27 counties, resulting from the decentralization of cultural heritage management after the Soviet era. For this reason settlement patterns will be analysed at different scales and relatively across the five chronological phases, in order to overcome biased point distribution.

An overall visual assessment of the data quality is shown below (Fig. 4.39), where the spatial distribution of site locations level of confidence is displayed. In the same way the degree of site visibility on satellite imagery is shown below (Fig 4.40). If compared, the two distribution maps highlight the areas where the quality of the data is more reliable, thus cross-validating and confirming the previous estimate (Fig. 4.36).

[24] See Appendix C.

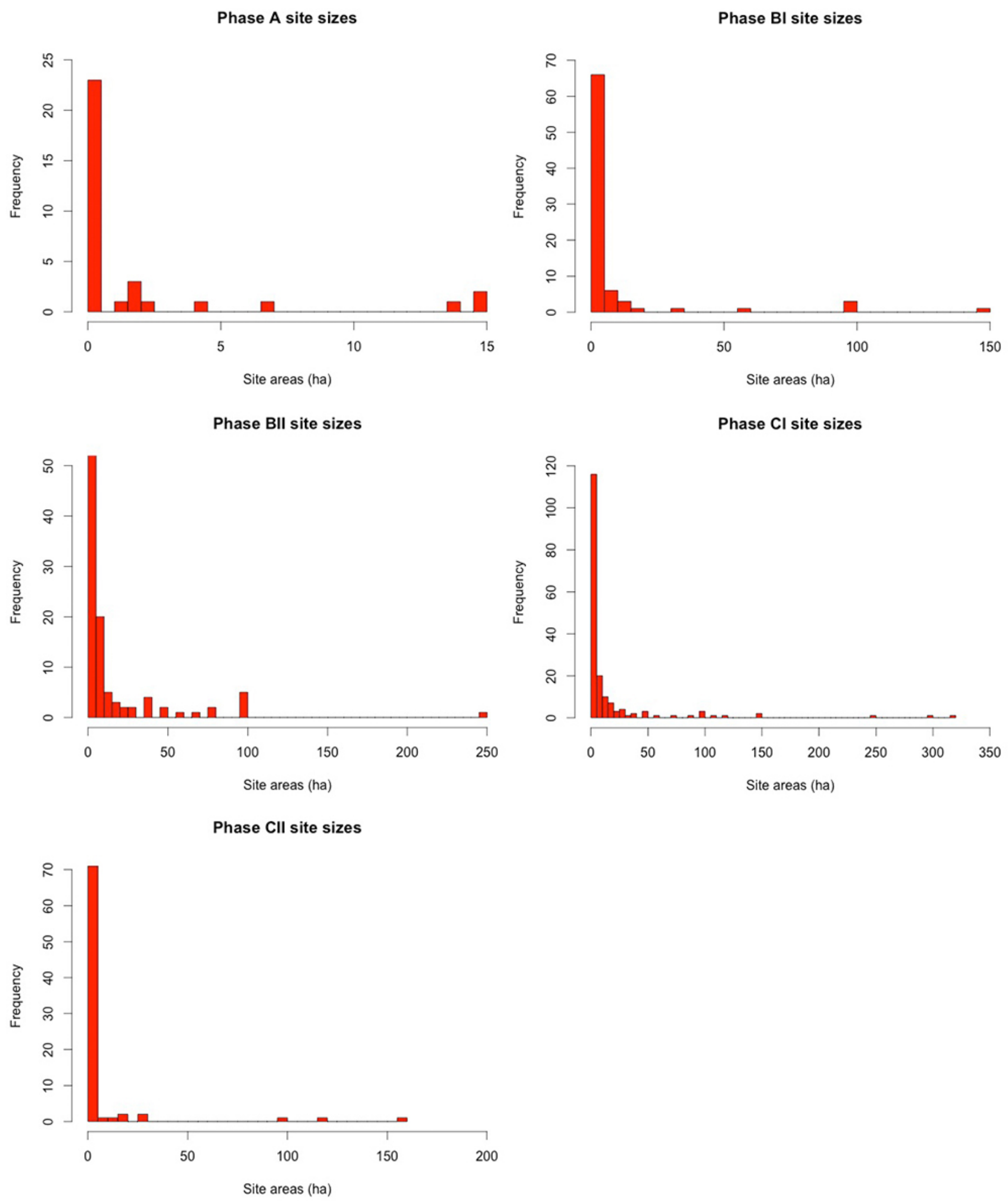


Fig 4.38. Histograms showing Trypillia site sizes by phase. Phase A (N=33); Phase BI (N=46); Phase BII (N=176); Phase CI (N=234); Phase CII (N=85).

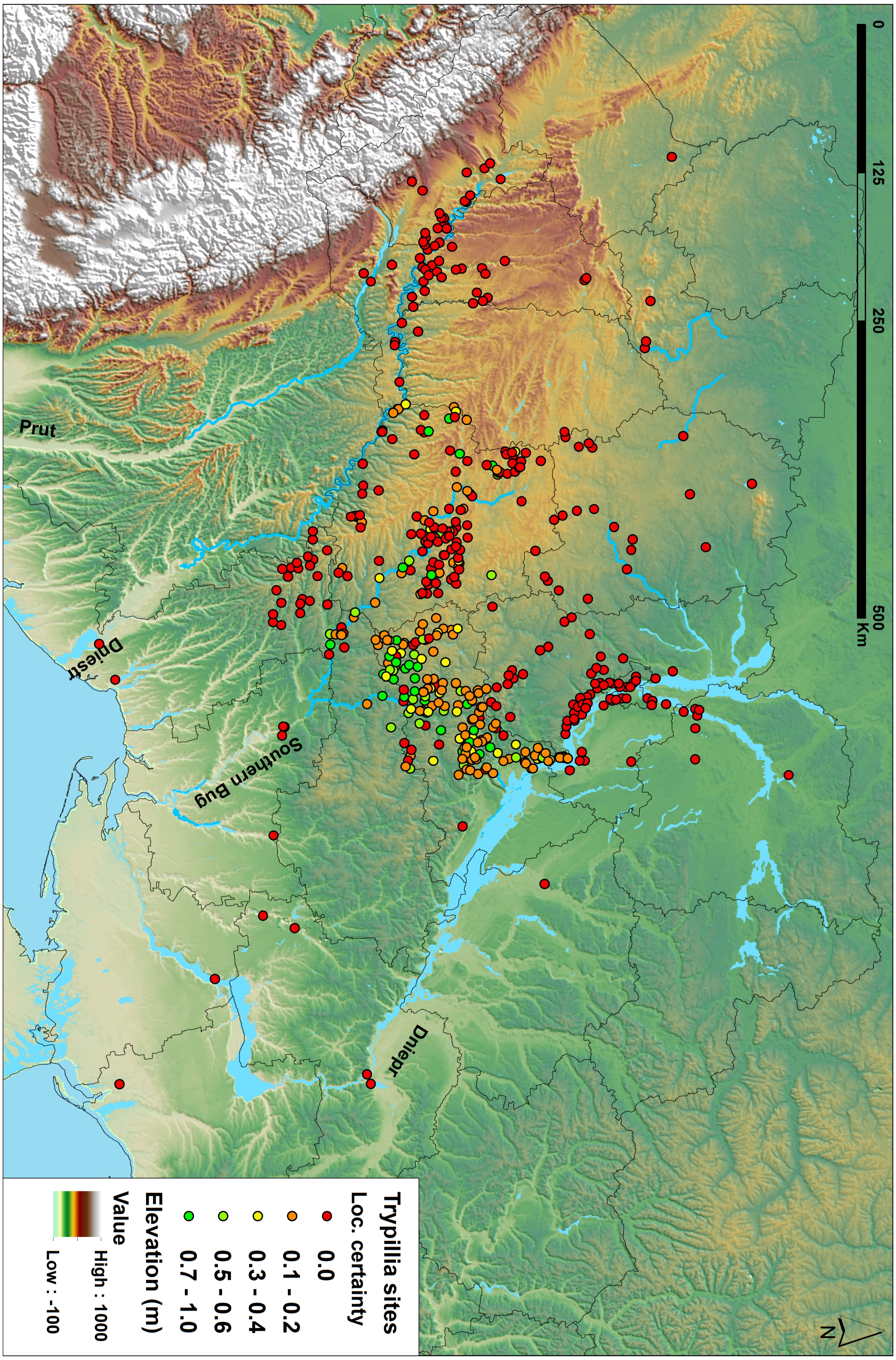


Fig 4.39. Map showing the distribution of the level of confidence for site locations.

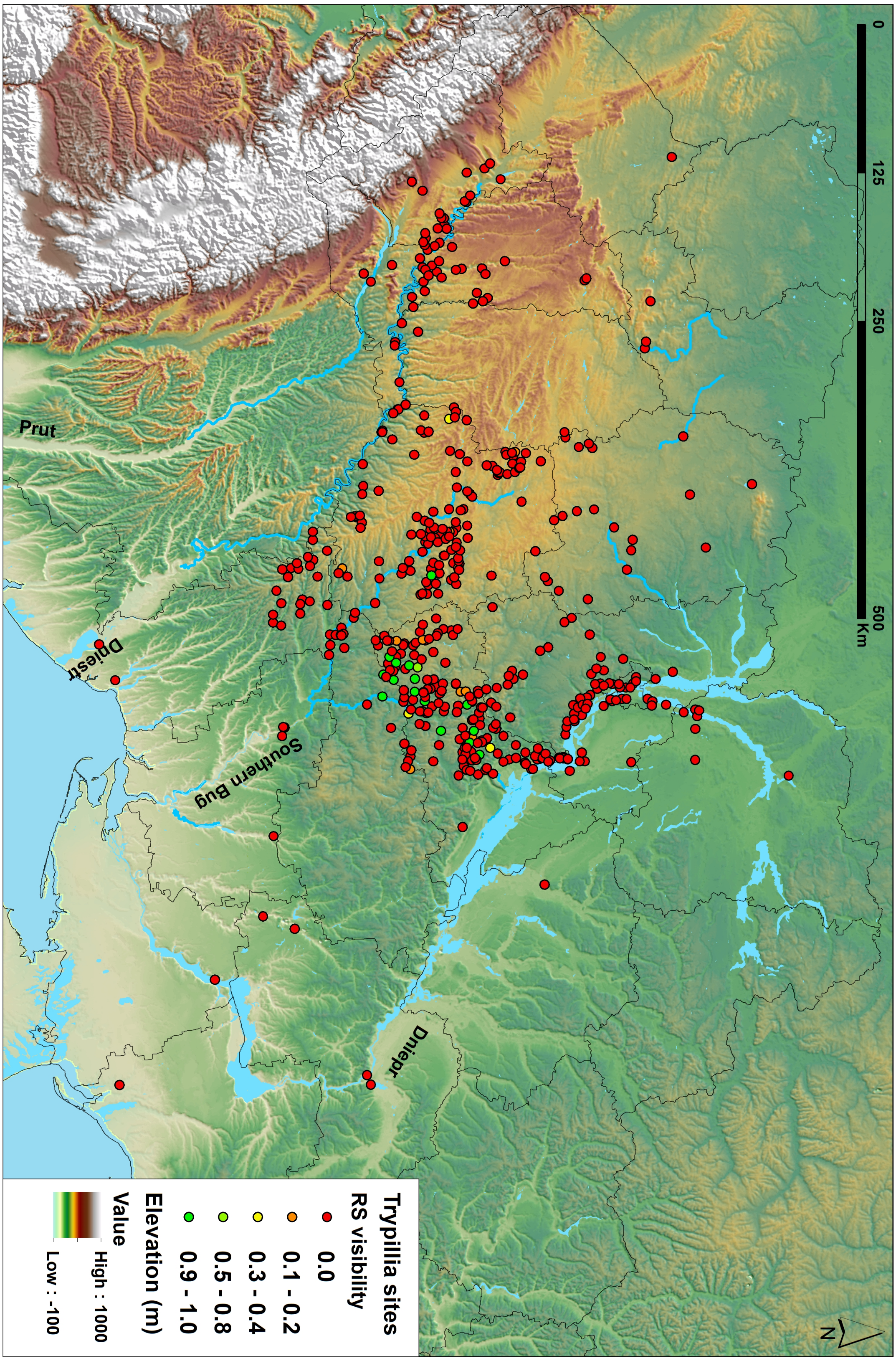


Fig. 4.40. Map showing the distribution of site visibility from satellite imagery.

An additional set of data has been recovered for Phase CII settlements, from an article published by Igor Manzura (2005), although only site locations are available. The absence of site size attributes prevented their inclusion in the quantitative analyses, which were mainly based on this piece of information. However, their contribution to the post-megasites settlement pattern and its social implications has been considered in Chapter 6. Fig. 4.41 shows the contribution of Manzura's dataset to the overall distribution of CII settlements. A scenario of settlements remarkably more clustered is shown, although the extent of the overall distribution of Phase CII sites is unchanged.

Overall, the procedures of data cleaning and database set up show how the process of "creating" archaeological data can dramatically change accordingly to the adoption of different methodologies. It is important to point out how dissimilar datasets can lead to quite diverse results and interpretations and these biases the whole exercise of archaeological investigation.

Having a full awareness of the data quality, especially when dealing with legacy data and grey literature, is fundamental, especially when the latter are the only available sources of information. So far within Trypillia studies archaeologists directed their attention either towards the biggest settlements or to the Bug-Dnieper interfluve where the majority of known sites is located. Scholars have tried to address the topic of early urbanism in Trypillia archaeology focussing either on the single mega-site or on the few known in the Cherkassy County. In the next Chapter we will see how the contribution of the 499 Trypillia sites extracted from the Encyclopaedia fundamentally contribute in the understanding of the nature and function of the largest settlements in the 4th millennium Europe.

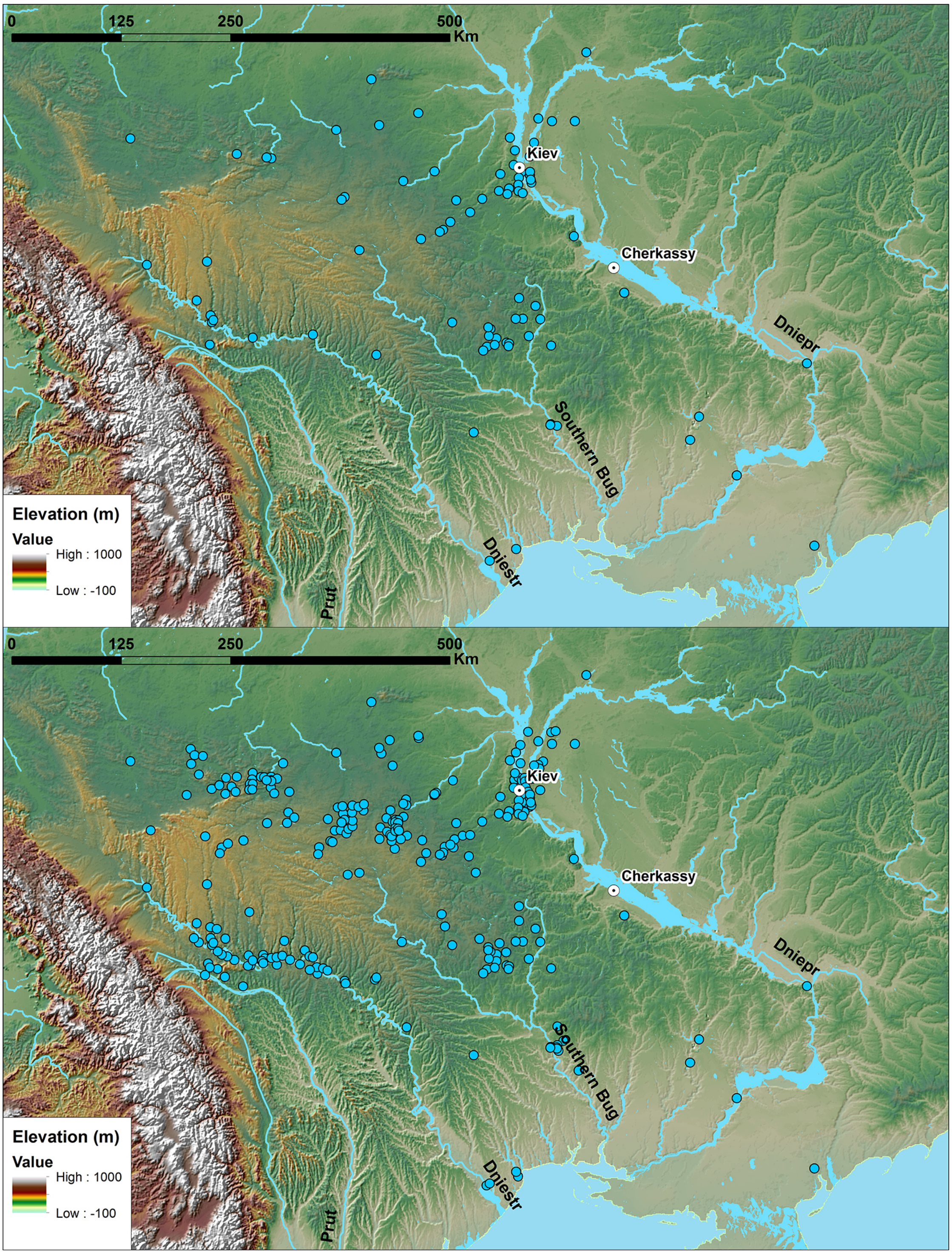


Fig. 4.41. Distribution maps of Phase CII settlements recovered by the Encyclopaedia (top) and from Manzura's article (2005) (bottom).

4.8 Conclusions

Chapter four represents the major methodological contribution of the thesis to Trypillia archaeology. Firstly, it discussed the first complete assessment of remote sensing as a tool for mapping Trypillia sites, highlighting limits and potential. Secondly, it elucidated the results of the first field survey conducted in continental Ukraine, and established a field methodology that can be adopted in future of Trypillia investigations. Lastly, it explained how the combination of remote sensing and field survey can develop a method to assess the bulk of legacy published data, which represent the core of the large-scale analysis of Trypillia settlement patterns that will be discussed in the next Chapter.

Chapter 5: Understanding settlement dynamics in the Trypillia group: a quantitative approach

5.1 Trypillia megasites history of investigations

The so called “Trypillia megasites phenomenon” has been the main focus of Neolithic archaeology in Ukraine for more than 120 years, with the awareness of these settlements developing early in the history of Trypillia studies. The first mention of a Trypillia settlement dates back to the very end of the 19th century, when Vikentij Khvoika noted a roundish-shaped site near the village of Trypillia, south of Kyiv (Khvoika 1901). After hearing of this discovery, Ernst von Stern started investigating the site of Petreni in modern Moldova during the first years of the 20th century, interpreting the burnt remains of the houses as residues of funerary practices and the pottery vessels as cinerary urns (Stern 1907, 62).

During the first half of the 20th century a number of excavations took place in several large settlements including Volodymyrivka, Maidanetske, Bilyi Kamin, Sushivka, Popudonia and Kolodyste, yielding numerous and diversified types of finds (painted pottery, figurines and house models made of clay) (Videiko 2002, 11-21). The main focus of archaeologists at this time was towards the single site, such as Volodymyrivka (phase BII), which has been surveyed and excavated extensively by T. Passek. With 200 houses detected from field survey and 27 excavated, Volodymyrivka was at that time - and probably still is - the best investigated Trypillia megasite (Passek 1949b). Passek also suggested for the first time formally that the “status” of these big sites is different from the other contemporary smaller settlements, terming Volodymyrivka a “patrimonial village” (Passek 1949a, 108).

Along with Passek, only a few other archaeologists speculated about megasites being “special places” in the Trypillia social system. The first person to interpret them as the first evidence of “proto-urbanism” was V. Petrov in 1947 (Petrov 1992, 18). It is interesting that Petrov worked on Volodymyrivka in the 1930s. Later, in 1965, S. Bibikov refered to the megasites as “centres based on clan systems” where interactions between Trypillia tribes occurred, seeing Volodymyrivka as an example of those (Bibikov 1965, 58).

First to acknowledge that a full understanding of the archaeological nature of these large settlements required an investigation of the full extent of the site and its surroundings was V. Kruts, who establish a nuanced sampling strategy at Chapaevka (Kruts 1977, 166). Kruts thus defined both a new theoretical and methodological approach to the Trypillia megasites by widening the ***scale*** of archaeological investigations.

Field-walking began to be adopted in order to survey large settlements, which have the problem of lying within modern agricultural fields with restricted access. One issue was that of surveying big sites covering more than one field unit. As a result, archaeologists mapped several independent sites which were in fact part of a large continuous settlement (Videiko and Rassmann 2016, 19).

This problem was mitigated through the use of aerial photography, which assisted the mapping of the megasites and allowed for a more complete overview. The first publication of an aerial survey of Trypillia sites came out in 1973, with 27 mapped settlements (Shishkin 1973).

By the beginning of the 1970s, the methodological revolution in megasite studies was taking shape, and a multi-pronged approach defined by the combination of remote sensing, field-walking, the first geomagnetic prospections and traditional excavations was tested on the CI site of Maidanetske in the Uman region by Shmaglij (Shmaglij et al. 1973). 1,575 archaeological features interpreted as burnt houses were mapped over 200 ha of settled area, representing the first complete plan of a Trypillia site (Shmaglij 1980) (Fig. 5.1). The programme of extensive geomagnetic prospections prompted the development of an intensive plan of excavations in which a sampling strategy was more carefully based on geomagnetic plans of the settlements. Between 1981 and 1991, a large number of burnt houses and other intra-site archaeological features were excavated (Videiko 1991; Shmaglij and Videiko 1990b; Kruts 1990; Markevich 1990; Zbenovich 1996).

At this point the question raised was how many houses were contemporaneously occupied within each megasite, as answering this question would provide fundamental insights into the interpretation of the nature and function of these massive settlements. Advances in dating techniques, such as ^{14}C and the improved relative chronology based on pottery seriation for the two main Trypillia phases - BII and CI (4100-3400 cal BC) - of megasite development (Kruts and Ryzhov 1985), allowed for an initial assessment of the internal chronology of Taljanki and Maidanetske. This showed that most houses were occupied at the same time, but some were erected earlier than others (Ryzhov 1990, 83-90; Shmaglij and Videiko 1990a). However, the standard deviation of the ^{14}C dates (ranging from ±29-33 to ±80-90) is too high for determining an internal development of the megasites and for working out a sequence of occupation of different megasites whether within or across Trypillia phases (Videiko and Rassmann 2016, 25).

Fig. 5.1. Final geomagnetic map of Maidanetske of Dudkin's surveys from 1971 to 1974 (Videiko 2005).

By the beginning of the 2000s, archaeologists started to raise further research questions probably prompted by the increasing amount of data and publications, including a massive two-volume Encyclopaedia of Trypillia Civilization (Videiko 2004; Videiko 2007; Ovchynnykov 2015; Korvin-Piotrovskiy et al. 2003).

Moreover, new lines of investigation have been pursued over the last decade of Trypillia studies, including archaeozoological data (Zhuravlev 2008), archaeobotanical data (Pashkevych 2012; Kirleis and Dreibrodt 2016), and new radiocarbon and AMS carbon dating (Telegin et al. 2003; Rassamakin and Menotti 2011; Müller et al. 2016).

Over the last few years, more extensive geophysical survey using modern techniques (Chapman et al. 2014; Chapman et al. 2014; Rassmann et al. 2014; Rassmann et al. 2016) provided new insights into the internal structure of the large settlements and the basis for a more bespoke intra-site sampling strategy.

Whereas all these investigations have been carried out at the megasite level of analysis, only very recently have archaeologists started looking at the "the other" settlements, coeval to the bigger ones, and tried to model movements and migrations within the Southern Bug-Dnieper interfluve (Diachenko and Menotti 2012; Diachenko 2012).

As discussed in the previous Chapter, no one has yet considered the full database of Trypillia sites (Videiko 2004), which, despite its limitations (see Chapter 4), cannot be completely discarded while trying to understand the formation processes and the nature of the megasites.

Since the beginning of the research on the Trypillia culture the focus has been towards the bigger settlements, but quite soon archaeologists realized that these were "special sites" and therefore attention should be now shifted towards the wider scale of the whole dataset of known Trypillia settlements in order to place the megasites in a broader context of settlement dynamics during the 4th millennium BC in Ukraine.

5.2 Defining megasites: a new scale of analysis

The theoretical definition of megasites has not been changed nor updated since the 1970s when the first complete geomagnetic plans were produced (Shmaglij 1980). Since then scholars have termed as 'megasites' those settlements whose areas extend beyond 100 ha (Fig. 5.2) and whose layout is defined by concentric circuits of dwellings, radial rows of structures and a more or less extensive empty space in the middle (Fig. 5.3). Further insights into the internal structure of megasites developed out of the "second phase of the methodological revolution" in Trypillia studies (Chapman et al. 2014), and this contributed to the discussion on whether there is a materialization of social structure inside these large settlements, thus providing new understandings within the wider discussion regarding their possible 'urban' nature.

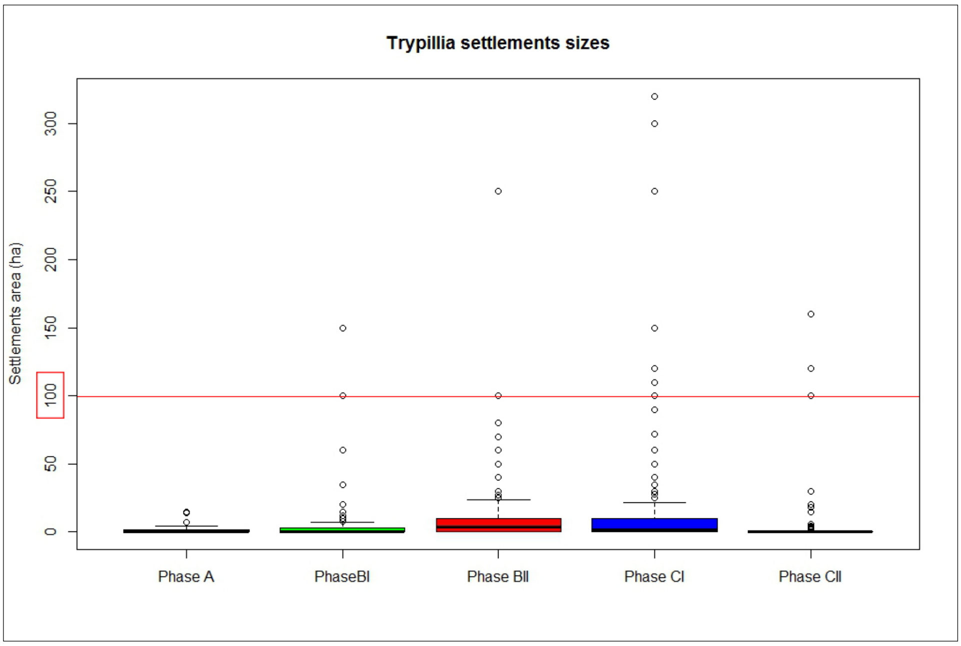


Fig. 5.2. Boxplot of sites areas reported in the Encyclopaedia by phase, showing the megasites sizes as outliers.

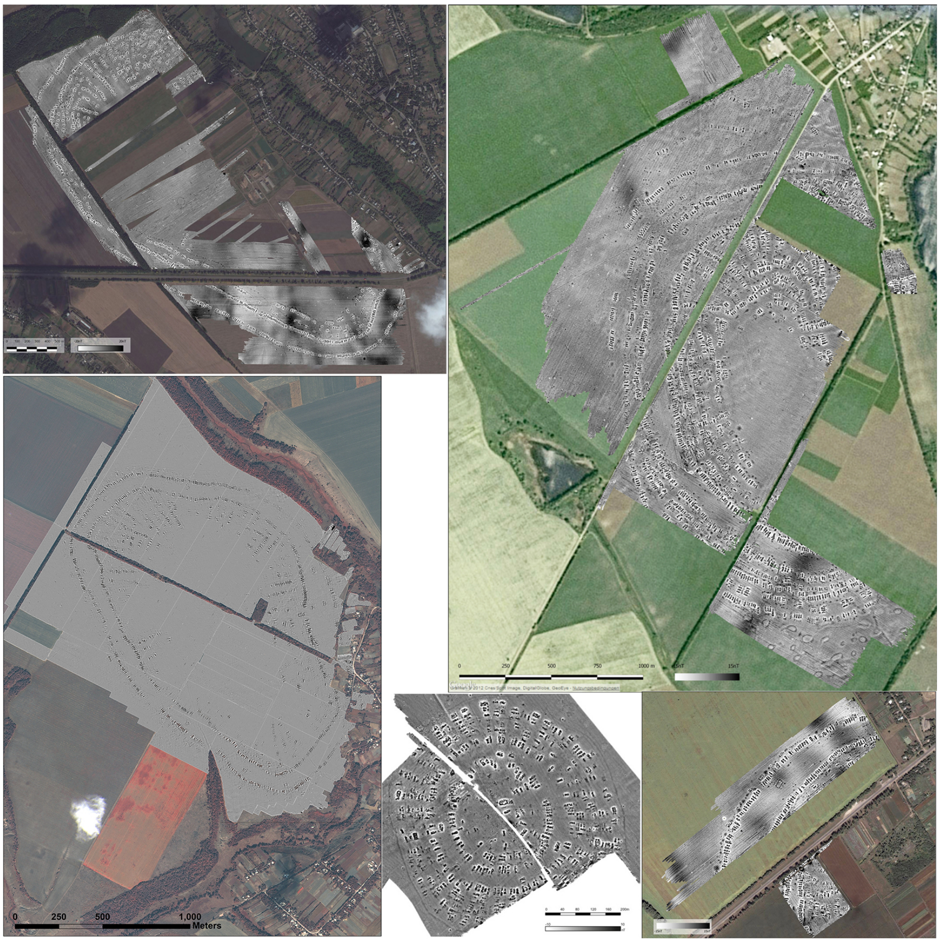


Fig. 5.3. High-resolution geophysical plans of Cucuteni-Trypillia megasites showing their typical "doughnut-shape" layout; from top-left corner clockwise: Taljanki, Maidanetsk, Dobrodovy, Petreni, Nebelivka (after Rassmann et al. 2014; Chapman et al. 2014).

For many years the focus of the research remained at the megasite level, trying to gather more information and data for the whole settlement. Only recently have archaeologists started to look at these large settlements in the wider contest of the Southern Bug-Dnieper interfluve 'system' or "Western Trypillia Culture" (WTC) (Diachenko 2010). Diachenko modelled movements and migrations within the Southern Bug-Dnieper interfluve - though including a limited number of sites in his network analysis - in the attempted process of re-discussing the chronological sequence of megasite occupation (Diachenko and Menotti 2012; Diachenko and Menotti 2015). Manzura studied Cucuteni-Trypillia settlement dynamics within the framework of the "colonisation" of the North Pontic steppe territory, but referred to megasites (or "super-centres") as evidence of a shift from an egalitarian tribal system towards a more complex societal organization in control of restricted resources from intensified production and exchanges (Manzura 2005).

Technological and methodological advances improved our understanding of the lay out and internal structure of megasites, but what Manzura and Diachenko demonstrated is the importance of considering the megasite phenomenon in the broader contest of coeval sites, rather than considering it as a separate social development. Unfortunately, we have not yet reached the same level of detail for the other Trypillia sites as we have for the biggest of the megasites. Nevertheless, it is worthwhile including in the research agenda the final database of sites derived from 'cleaning' and selecting the information contained in the Encyclopaedia of Trypillia Civilization; Videiko 2004; see Chapter 4). Being fully aware of the paucity of the information taken into consideration, this thesis will show the insightful contribution of the Encyclopaedia data towards a more thorough understanding of the megasite phenomenon.

This hints at a new definition of megasites based on their spatial relationship with other settlements. Since the quality of the database is temporally consistent over the five Trypillia phases, and that Cherkassy (where the majority of the megasites is located) is not the only region with a good dataset (Fig. 4.8), we can assume that diachronic analysis of settlement patterns for the two millennia of the Trypillia period are to be taken as real patterns and not excessively biased by data collection and data quality. The chronological resolution based on pottery typology is 300-400 years (Kruts and Ryzhov 1985; Ryzhov 1990; Ryzhov 1993; Ryzhov 1999; Ryzhov 2000; Ryzhov 2007), the site location accuracy is 1-2 km, and the site size accuracy is difficult to assess but is random across the sample. A useful heuristic device to be adopted, in order to overcome a number of problems in the survey data (discussed in Chapter 4), is a trans-scale tactic where patterns in the data are analysed at both different temporal and spatial scales and where the continuity across scales is considered and respected, even if using scalar categories such as ***macro-meso-micro*** to facilitate the analysis (Knappett 2011, 10).

The scale of analysis allowed overcoming these inaccuracies in the data and the final interpretative model has been designed to be dynamic so as to include new data coming from future research.

Pursuing an inter-scalar approach, five lines of investigation have been pursued in order to define the spatial relationship and the formation processes of the megasites in the territory of Ukraine.

1 – Megasite locational strategies: is there a correlation between the locations of megasites and the locations of the other Trypillia settlements?

2 – Size hierarchies: does the first appearance of megasites in phase BI introduce a level of hierarchy in site sizes and what happened during phases BII and CI when the phenomenon developed?

3 – Size clustering: are the settlements nucleating with the appearance of the megasites and at what scale is the clustering statistically occurring?

4 – Megasite micro-hinterland patterns: what is the settlement pattern of megasites' micro-hinterlands (5 km)?

5 – Megasite relative capacity: how many people could dwell in a megasite at any one time?

The answers to the five questions posed here constitute the main evidence on which the final interpretative model is based. This defines the point where the PhD research path splits from the underpinning project and by working parallel to it provides insightful contributions to the overall research questions. Overall, a regional and contextual perspective (Kantner 2008) is the sole approach that allows for a full understanding of settlement patterns and, most importantly, the underpinning settlement systems of a specific socio-cultural-economical entity (Flannery 1976b, 162).

An initial data mining process will 'extract' patterns in the data collected and managed, which will constitute the basis for the interpretative model that will provide a nuanced explanation of the nature and function of Trypillia megasites.

We now turn to the results of these analyses.

5.3 Megasites locational strategies: why are they where they are?

A simple plot of all the Trypillia settlement data on a map shows that there is a concentration of megasites in the Southern Bug – Dnieper (henceforth SBD) interfluve, within the region of Cherkassy (Fig. 5.4). A total of 20 out of 23 megasites (defined by size = over 100 hectares) are located in a megasite cluster (henceforth ***mega-cluster***), whereas 3 are situated in a more marginal[25] area spanning the whole Trypillia territory. At first glance it would seem that the SBD interfluve constitutes the "core" of the Trypillia people, whereas the rest of the sites represent the "periphery"[26], and probably that is one of the reasons why archaeologists focussed their attention mostly on the cluster rather than considering the whole volume of available data (see section 5.1).

Regardless of the nature of the relationship between the two macro-patterns, it is clear that there is a predominant locational strategy for the development of megasites, which prompts the question: why are they where they are? Is there an environmental reason why they developed in that specific territory? Or maybe other explanations are possible?

In order to answer these questions, I adopted an Occam's razor approach and tested the 'simplest' hypothesis that megasites are mostly located in the SBD interfluve for environmental reasons. Hence, the null hypothesis to be tested is that the presence of a megasite is dependent on specific geomorphological conditions, better connection to waterways, and more fertile soils.

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[25] Here the term marginal is conceived as "not part of the cluster" and not in terms importance and significance.

[26] See (Wallerstein 1974) for core-periphery theory and (Friedman and Rowlands 1977) for first application to archaeological research.

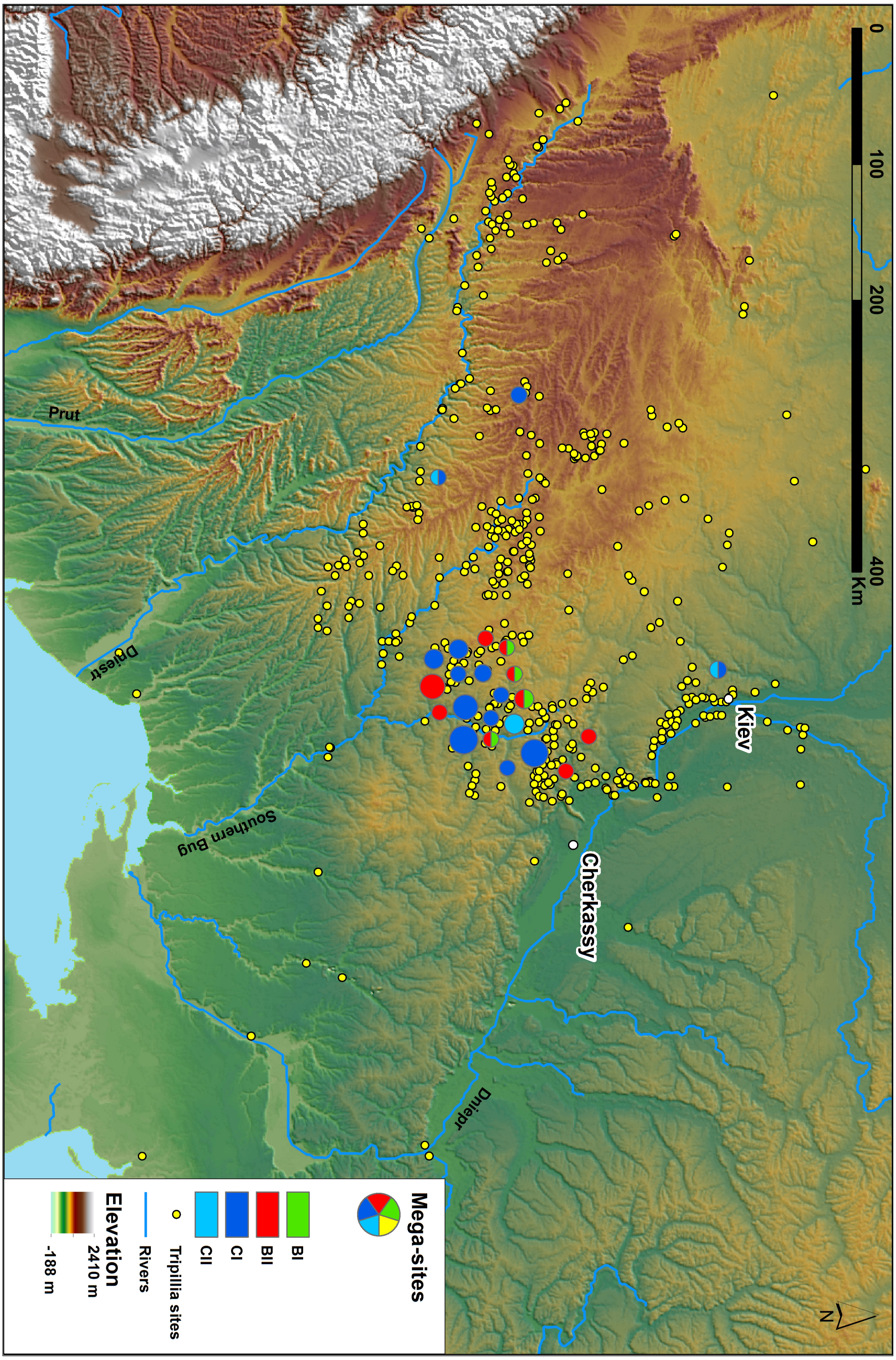


Fig. 5.4. Distribution map of the known Trypillia settlements highlighting the location of megasites in the Southern Bug-Dnieper interfluve.

The most common way of testing this hypothesis is a classic logistic regression (Cox 1958), which has been used in archaeology typically to create the base for predictive modelling (Kohler and Parker 1986; Espa et al. 2006; Carrer 2013; Kvamme 1983; Kvamme 1985). Logistic regression has been used within so-called ‘inductive’ (or ‘correlative’) approaches to predictive modelling; a data-driven method relying on empirical site location strategies tested on existing archaeological evidence (Wheatley and Gillings 2002, 149). The major critique of this approach is that it does not account for cultural or rather non-environmental-related factors guiding past actors’ decisions as to where to settle, particularly the way people perceived or thought about the landscape (Bevan and Conolly 2006; Bevan and Conolly 2009; Verhagen and Whitley 2012, 51). Moreover, problems arise when independent variables present spatial dependence, which is often the case with different environmental contexts (Fotheringham et al. 2000, 162-166).

Nevertheless, logistic regression is here simply used to test whether megasite locational strategies differ from those of the other Trypillia settlements and, if so, to understand whether these are related to different geographical settings or to diverse unquantifiable reasons.

The test developed in two phases. First, an assessment that overall Trypillia settlements follow an environment-based locational strategy, and a second part to test whether megasites sit in specific environmental settings when compared to the other sites or not.

5.3.1 Logistic regression test

Aligned with the Occam’s approach of opting for the simplest hypothesis first, it has been assumed, as a null hypothesis, that the presence/absence of a Trypillia settlement is directly correlated with specific environmental variables. As environmental variables, I opted for the four more comprehensive and general ones such as elevation (SRTM 30 m res.), slope (derived from SRTM 30 m res.), distance from rivers (river network extracted automatically from SRTM – and classified using Strahler stream order (Strahler 1952) and soil types[27] (Fig. 5.5). The inductive method is based on actual archaeological evidence that forms the basis of determining the environmental condition in which Trypillia sites are located. These conditions have to be tested against a series of background “non-site” locations to see whether the presence/absence of real archaeological settlements it is statistically correlated to the environmental variables (Goings 2010).

[27] Soil types are derived from a Soviet soil map published in 1977.

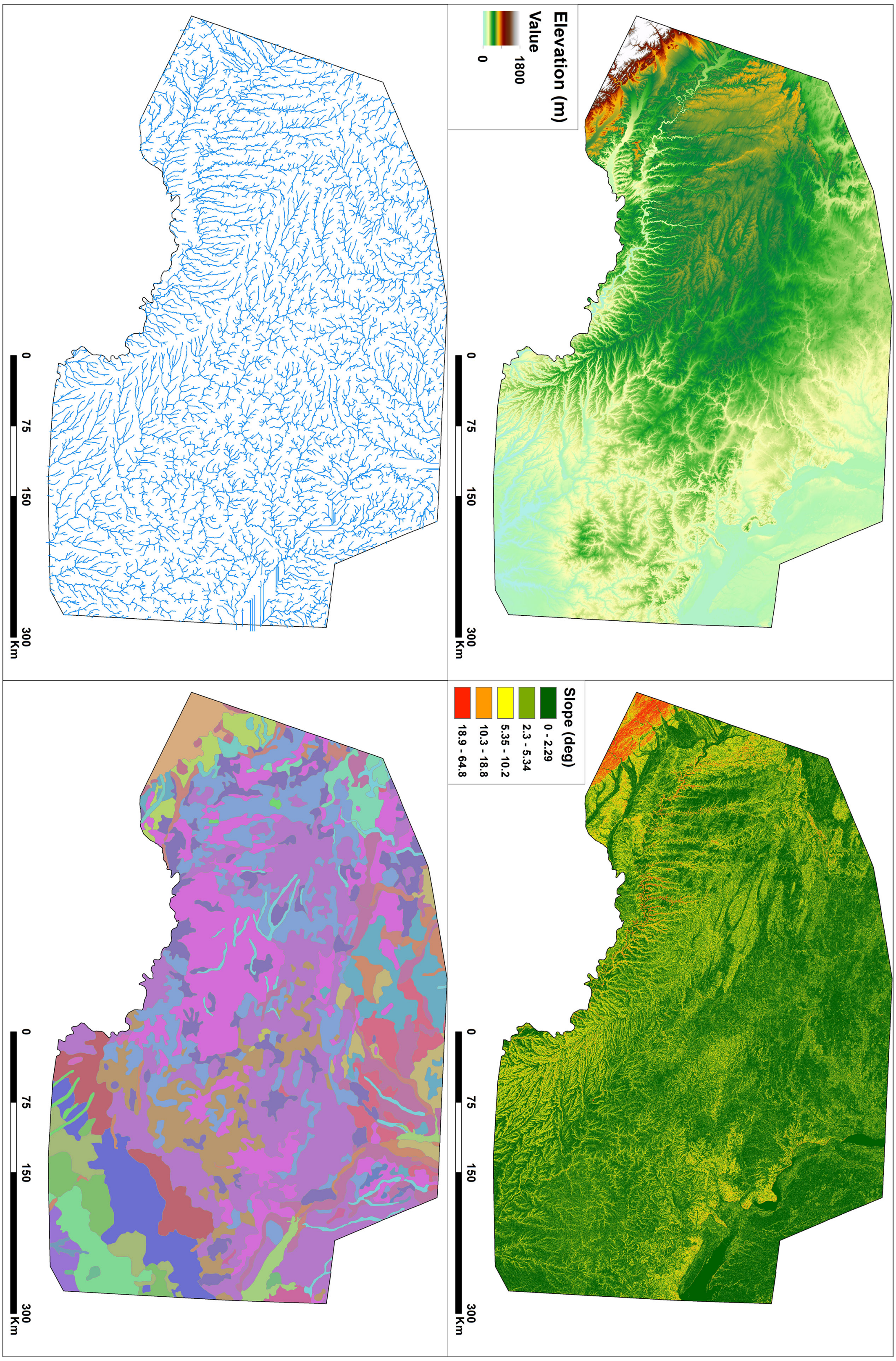


Fig. 5.5. Environmental variables considered in the logistic regression. (From top left clockwise) a) Elevation (source: 30 m res. SRTM); b) Slope (derived from 30 m res. SRTM); c) Soil types; d) Distance from rivers.

A regular background sampling of "non-site" locations (20 km spacing) has been generated in GIS[28] in order to obtain a sample that comprises the full variation of each independent variable (Kvamme 1992, 28) (Fig. 5.6)[29].

The results of the logistic regression test (Table 5.1) show how the location of Trypillia settlements overall are strongly correlated (p-value < 0.05) with the independent variables, thus showing an environmental-driven locational strategy.

Factors	**Estimate**	**Std. Error**	**z-value**	**p-value**
(Intercept)	1.388e+00	2.422e-01	5.732	9.94e-09
River_dist	-5.869e-04	7.121e-05	-8.241	< 2e-16
Elevation	-2.887e-03	9.839e-04	-2.934	0.003345
Slope	1.053e-01	2.638e-02	3.992	6.54e-05
Soil type	4.483e-02	1.153e-02	3.889	0.000101

Table 5.1. Summary of the first logistic regression test run on all the Trypillia sites and the "non-sites" sample.

[28] The working space has been set based on the distribution of Trypillia sites. 5 sites have been excluded as they are located to far from the main distribution and might have had and edge effect bias on the model.

[29] The model has been tested also with a random distribution of "non-site" locations and that produced similar results.

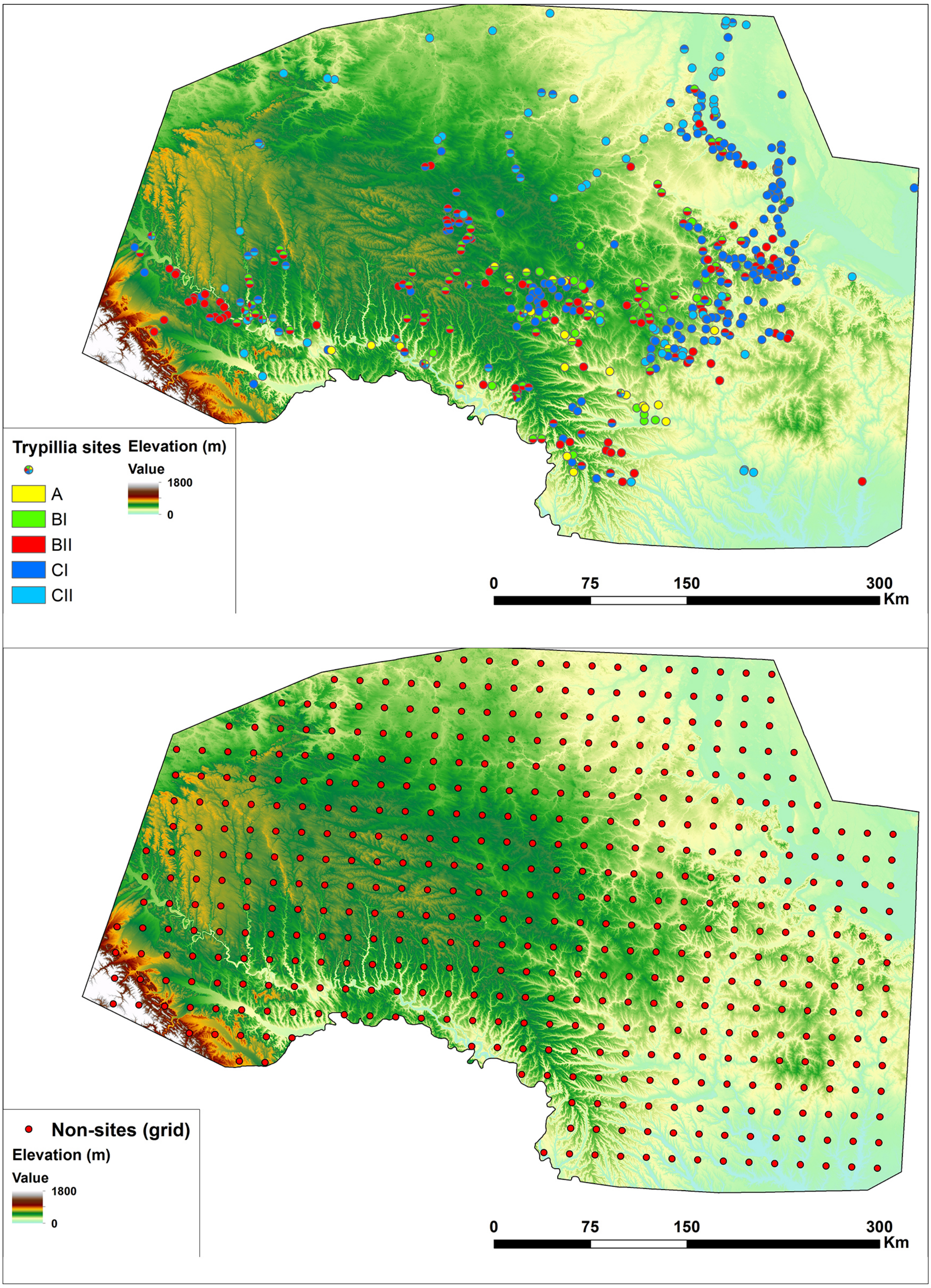


Fig. 5.6. Distribution of the real archaeological data (top) and the regularly spaced "non-site" locations, used in the logistic regression model.

The most significant correlation seems to be between site locations and distance from rivers. The negative estimate shows how the further the location is from a watercourse, the lower the possibility of finding a Trypillia site. This result is biased by the traditional way of field-walking in the Ukraine, mainly along riverbanks[30]. However, new extensive and systematic field survey carried out around the megasite of Nebelivka confirmed this pattern of sites being located along riverbanks and not in interfluvial areas. This pattern is also confirmed for settlements of later periods, with the exception of burial mounds or "kurgans". Most importantly, this pattern is not correlated to site size, as it has been observed for both megasites and smaller settlements in the surveyed territory.

Overall, it has been shown that Trypillia site locations have a significant correlation with the environmental conditions.

The second part of the test is to check whether megasites and sites in the SBD interfluve are situated in specific environments compared to the rest of the sample. This will provide an insightful contribution to understanding the reason why people would have chosen to settle in the SBD interfluve and more generally on the relationship between megasites and smaller settlements.

The same logistic regression model has been then used to test how the presence/absence of SBD interfluve settlements (N=156) correlates to environmental variables compared to the rest of Trypillia sites (N=330). Namely, the SBD subsample has been used as archaeological sites and the rest of Trypillia settlements as "non-site" background locations (Fig. 5.7). In this way it was possible to establish whether locational strategies of SBD interfluve sites differed from the rest of Trypillia settlements for environmental reasons or not.

Factors	**Estimate**	**Std. Error**	**z-value**	**p-value**
(Intercept)	3.520e-01	3.945e-01	0.892	0.372184
River_dist	1.563e-04	9.984e-05	1.565	0.117604
Elevation	-6.726e-03	1.764e-03	-3.814	0.000137
Slope	-7.719e-02	3.579e-02	-2.157	0.061024
Soil type	3.577e-02	1.914e-02	1.869	0.061659

Table 5.2. Summary of the second logistic regression model comparing SBD sites with the other Trypillia settlements.

The results (Table 5.2) show how there is no statistical dependency (p value > 0.05) between SBD sites and environmental variables when compared to the rest of Trypillia settlements. Elevation seems to be the only independent variable that is contributing to site locational choices.

[30] Firstly discussed and criticized by Kruk for Central Europe (Kruk 1980, 1-7).

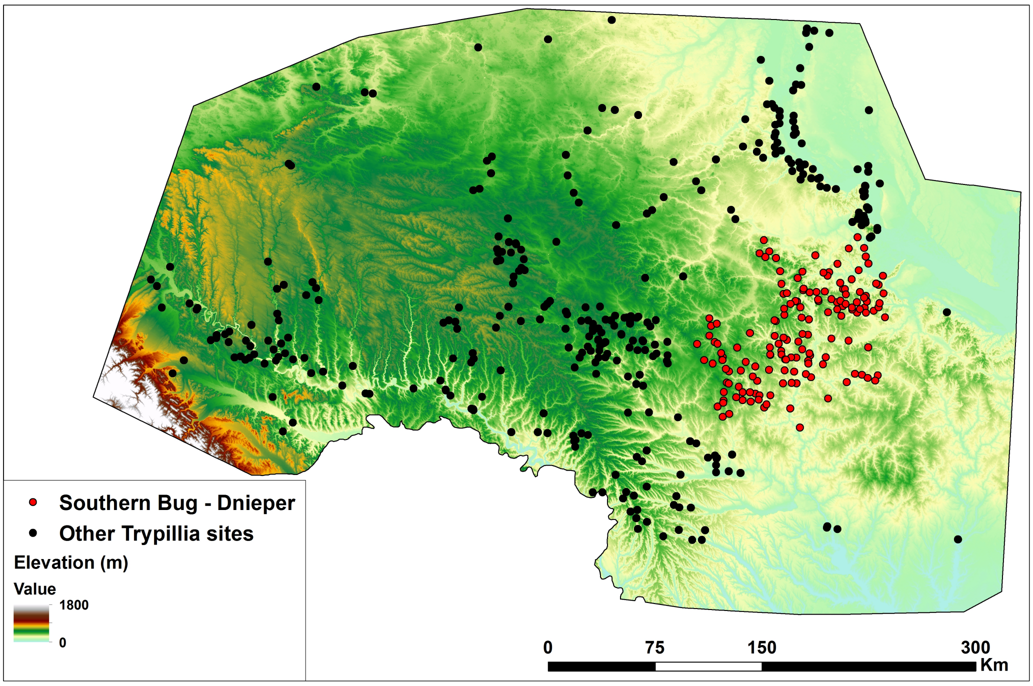


Fig. 5.7. Distribution of Southern Bud-Dnieper interfluve sites (red) and other Trypillia settlements (black) used as "non-sites" locations in the second logistic regression model.

Nevertheless, this can be explained by the fact that elevation is the only variable to be spatially dependent, namely there is a general decreasing trend in the elevation data from NW to SE. It is noticeable that there are no archaeological data for the region SE of the SBD interfluve[31], which, therefore becomes the lowest territory settled during the Trypillia period.

Overall, it can be argued that it does not seem to be an environmentally-linked reason why Trypillia people decided to settle and develop such massive sites in the SBD interfluve. The evidence here presented go against any argument that megasites developed in this territory because of more favourable environmental conditions (such as better soils for agriculture)[32](Ohlrau et al. 2016). Furthermore, there is no evidence for either a particular concentration of flint sources in SBD interfluve or salt sources (Chapman and Gaydarska 2003, Fig. 1).

Hence, we can argue that this analysis suggests that there must be other reasons why megasites developed mainly in the Southern Bug – Dnieper territory, perhaps more related to the social rather than the environmental sphere.

[31] The regions SE of Cherkassy and Kirovograd oblasts are notably archaeologically unexplored, as yet.
[32] This is also supported by the fact that SBD is not the most fertile territory in the Ukraine.

5.4 Site size hierarchies

Since site locations, site sizes and relative chronologies are the only information we have for the whole sample of Trypillia settlements, as derived from the Encyclopaedia, I tried to get the most out of each of them considering the new scale of analysis that the complete Trypillia database allows. In the last section I focussed on site locations, whereas the next four lines of investigations will be dealing with site areas across the five Trypillia phases, analysed in different ways.
In this section I will explore the variability of site sizes within each phase and how the variability changes through time with the development of the megasites. The implication of this analysis will provide useful insights on the overall Trypillia settlement patterns and more specifically on the nature of the largest sites.

Mostly, archaeologists talked about site size hierarchies when dealing with variability in site areas within the same 'cultural' and 'political' contest, and soon took this (in the absence of monumental architecture) as evidence for political or social stratification/hierarchy (Creamer and Haas 1985; Earle 1987; Gilman et al. 1981; Johnson 1977; Liu 1996; Peregrine 2004; Ellis 1984). More recently, scholars have moved away from this static and consolidated paradigm, and argued for multiple explanations for the formation of site size hierarchies, thus moving beyond a constraining correlation (Flannery 1976a; Flannery 1976b; Keswani 1996; McIntosh 2005; Parkinson 2002; Peterson and Drennan 2012). The development of alternatives for explaining site size hierarchies is also fundamental for a more thorough understanding of Eastern European settlement patterns (Galaty 2005; Kowalewski 2008), and new theoretical frameworks alongside new methods are needed in order to fully comprehend settlement patterns as more primary data is produced. As Duffy clearly synthesized, there are a number of different reasons and processes that can lead to the development of a site size hierarchy within the same cultural and political framework (Duffy 2015). In this research the analysis of site size hierarchies has been used for data exploratory purposes and definition of different settlement patterns between the SBD interfluve and the rest of the Ukrainian forest-steppe territory, particularly in relation to megasites development: have they affected site hierarchies? And if yes, how?

The analytical tools adopted for the exploration of the data are: histograms, the GINI coefficient and the Kernel Density Estimation (KDE).

A series of histograms representing site sizes for the five Trypillia phases indicates how each phase, at different scales[33], shows a degree of size hierarchy (Fig. 5.8).

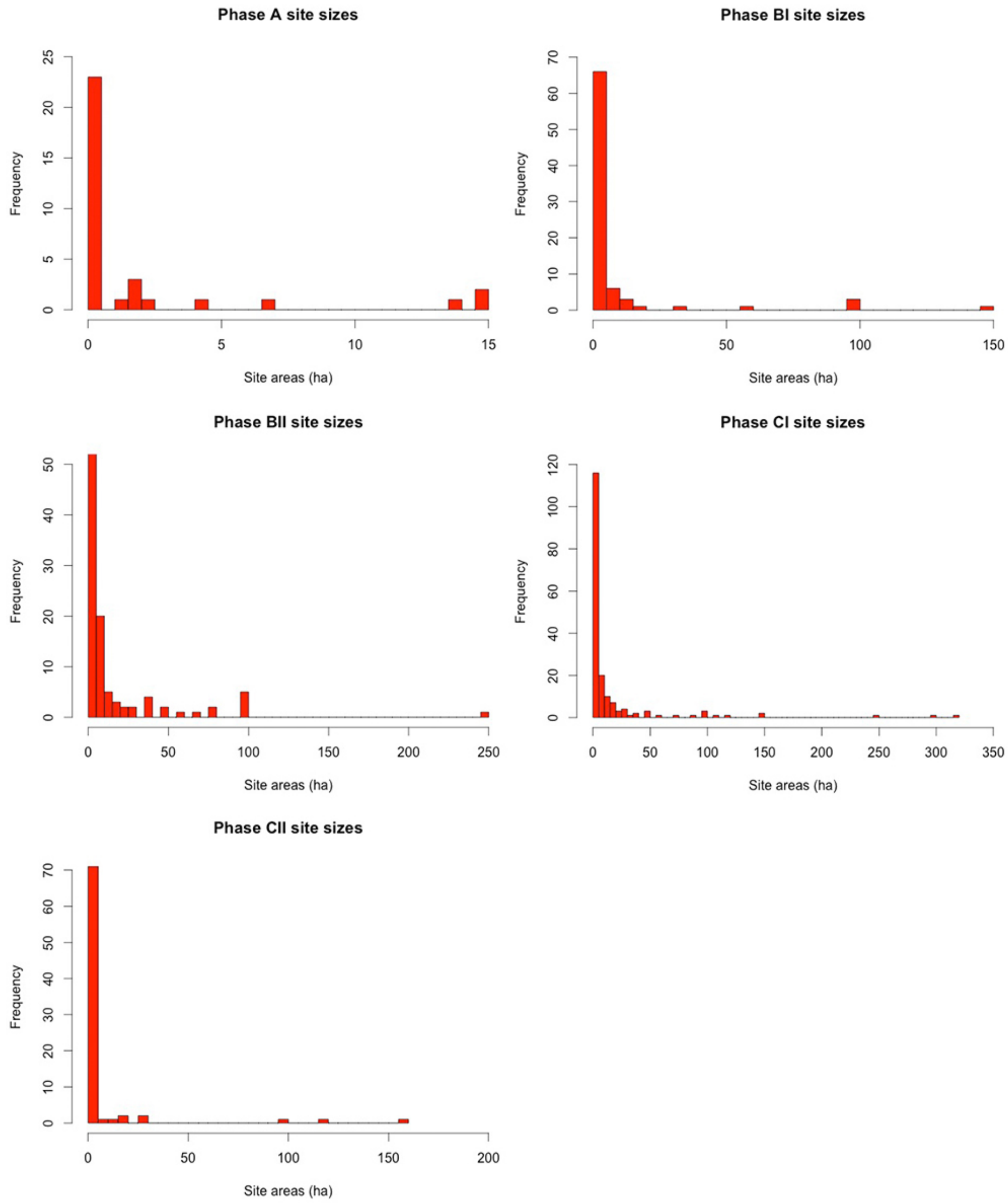


Fig. 5.8. Histograms displaying Trypillia site sizes by phase. Phase A (N=33); Phase BI (N=46); Phase BII (N=176); Phase CI (N=234); Phase CII (N=85).

[33] Xlims and binwidths are optimised and therefore different for each plot.

The data appear to follow a "Primate Pattern" distribution – a typical indicator of social hierarchy and of regional centralization - where there is a peak for small areas and a long tail of fewer bigger sites (Milisauskas and Kruk 1986, 25; Drennan and Peterson 2008, 360). It seems that for each phase there are one or more very large sites (=megasites) which stand out from the "expected" unimodal Poisson distribution. Simple visual inspection of the histograms prompts the conclusion that, from a system theory point of view, those are the centres of the system (Bentley and Maschner 2003). Drennan and Peterson criticise the fact that this interpretation is adopted, most of the time, without really statistically testing whether the largest values "depart" from the normal Poisson distribution enough to be considered 'dominant centres' (Drennan and Peterson 2008, 361). They therefore propose a solution to test this by using rank-size analysis especially for smaller regional scales where the convexity of the graph is not so evident (Drennan and Peterson 2008, 364).

The strong limitation of these analytical tools is that they rely on survey data, which have poor information on the internal structure of sites (Cherry 1983, 379) and their typology or function (e.g. intra-site craft specialization) (Flannery 1976b, 163), if indeed they are useable at all for interpretative purposes (Hope Simpson 1977, 213-217).

However, the approach followed in this research is to consider broader patterns in the data at different scales across the Trypillia phases. The starting point is to consider the megasites as statistical outliers in the overall site hierarchies. Furthermore, histograms show the gap between the high frequency of smaller sites and the very large ones with the absence of middle 'tiers'.

The first step was then to assess the effect that the development of megasites had in terms of site size hierarchies. In order to do that I used the GINI coefficient[34] as a measure of data 'inequality' (Gini 1912).

The coefficient has been applied in archaeology in recent years mostly to estimate social inequality within the single site or between sites, based on grave goods as a proxy of wealth (Bowles et al. 2010; Windler et al. 2013). In this case, it has been used to assess the influence of the megasites in the size variability/hierarchy at each phase (Fig 5.9). The graph shows how the initial development of megasites during Trypillia BI prompted an increase in size 'inequality', thus establishing a hierarchical pattern in site sizes. Throughout Trypillia BI, BII and CI, the size 'inequality' remains quite stable if not showing a slight decreasing trend, even though the number of

[34] For its use see Chapter 4.

megasites (>100 ha) increases exponentially and proportionally with the other settlements (Fig. 5.10).

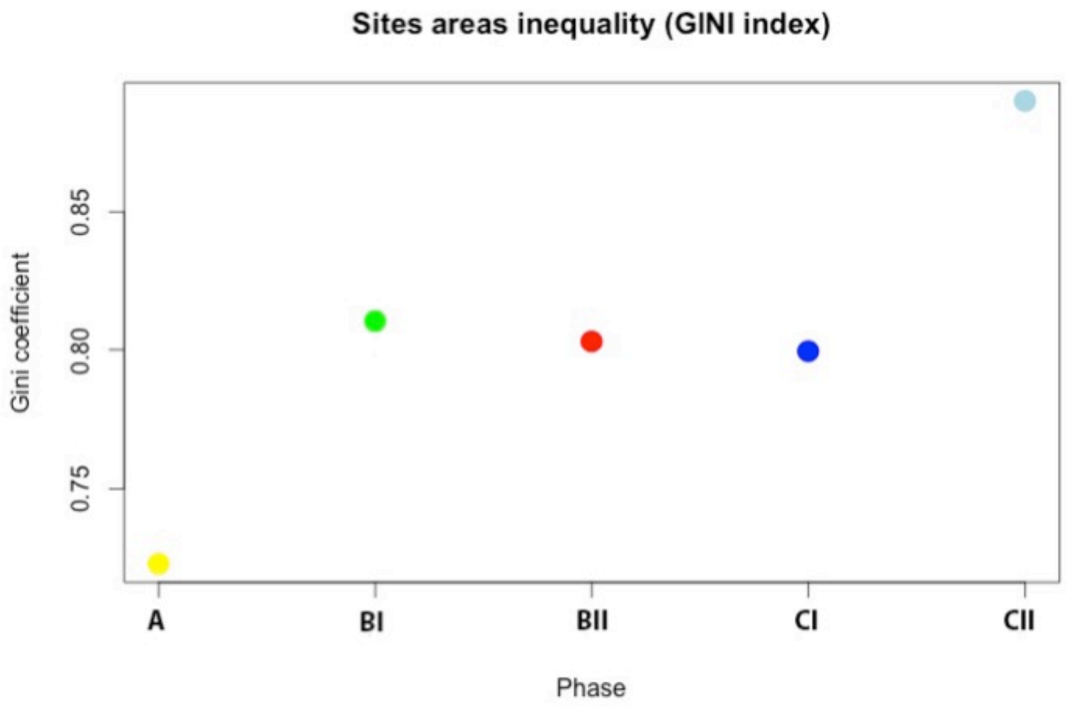


Fig. 5.9. Plot of GINI coefficients of Trypillia site sizes by phase.

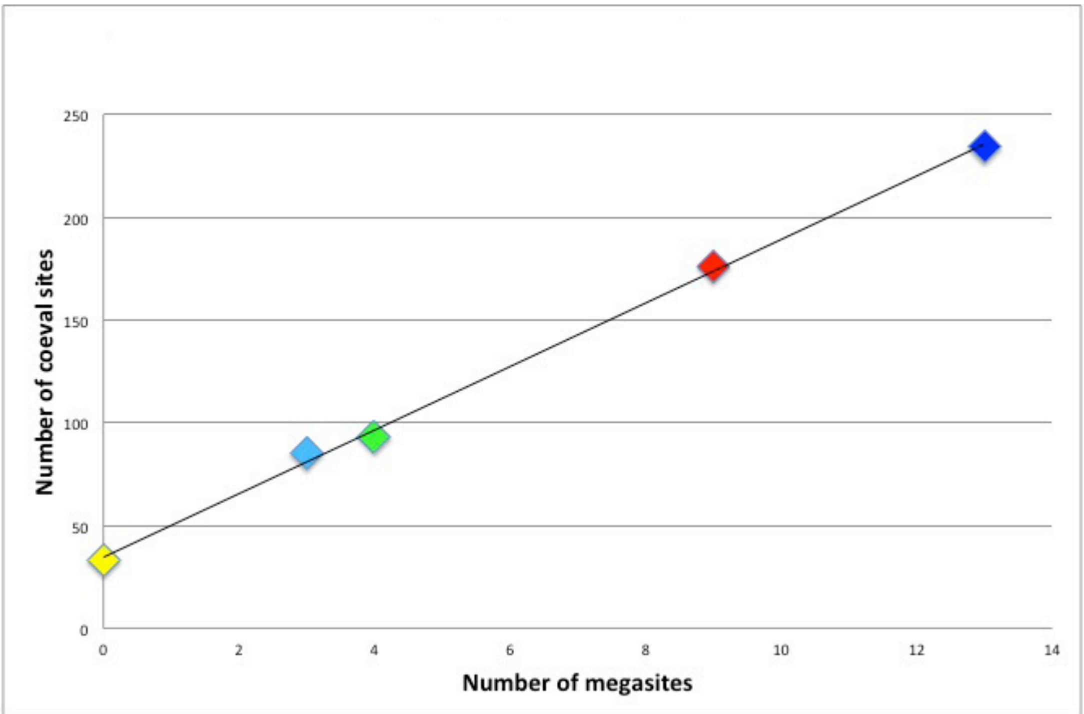


Fig. 5.10. Plot of Trypillia megasites and other settlement counts by phases. (same colour code as Fig. 5.8).

This suggests that during the three middle Trypillia phases (~ 4100-3400 BC) the appearance and development of such large sites did not correspond with a parallel development of a strong hierarchy in settlements sizes. Regardless of whether site size hierarchies are considered evidence of political organization in the case of the Trypillia, we are not facing a materialization (at the regional level) of any supra-local political or administrative structure.

This pattern is visible at a global scale, but what happened locally, and more specifically in the SBD interfluve and in the rest of the territory under investigation?

5.4.1 Kernel Density Estimation (KDE): an analytical tool for investigating relative site size hierarchies

Histograms have a number of limitations due to the way data values are displayed and plotted: namely the point of origin and the width of the bin (=bar). This can become a problem in analysis of multimodal data, where the number of modes depends on the choice of points of origin or bin-width (Whallon 1987, 146). Because of these limitations, Kernel Density Estimation (henceforth KDE) is a represent a better approach to display the data (Beardah and Baxter 1995; Baxter and Beardah 1996). KDE is a non-parametric estimation of the probability function (or density) of a random variable, where the kernel (or bandwidth) defines the way the function is represented, thus affecting the number of modes in the data (Rosenblatt 1956). KDE has had a number of applications in archaeology, ranging from material culture analysis to population estimates (Bevan and Conolly 2009; Bocquet-Appel et al. 2005; Zimmermann et al. 2009; Crema et al. 2010; Crombé et al. 2011). Nevertheless, KDE has never been applied to settlement pattern analysis and more specifically to investigate site size hierarchies. The potential of this analytical tool for studying size distributions has been shown in a number of applications in plant biology (e.g. Downing et al. 2014), but never really been taken on board by archaeologists in the investigation of settlement patterns at any scale. The purpose is here to present a potential application of KDE to investigate the different patterns in site sizes occurring in the settlements located in the SBD interfluves, compared to the ones located in the rest of the Trypillia area of influence.

The idea here proposed is that the analysis of the modes in the KDE function (Silverman 1981) can be considered as a way of identifying size hierarchies when data present multimodal density estimates.

Plotting of the KDE of sizes for SBD interfluve sites and the other Trypillia settlements for each phase allows a comparison of the modality of the data in the two regional samples. KDE are preferable to histograms especially when comparing multi-modal data – such as site sizes - (Baxter et al. 1997, 349), but the choice of the bandwidth is still affecting the representation of density estimations. Therefore, a proper comparison of the two plots requires them to have the same bandwidth. There are a number of ways to choose the right bandwidth and generally software can calculate the optimal width according to the data (Silverman 1981; Jones et al. 1996). The analysis has been conducted in R using the density function in the generic CRAN[35] mirror. In order to calculate the KDE an individual 'kernel' is centred at each data point (in the shape of a normal ("gaussian") distribution). The 'kernels' are then summed to obtain the KDE for the whole sample of data (Baxter 2003, 30). The bandwidth then is used to set the way to display the KDE (the sum of each kernel) in the final plot, and this value determines the way the density estimates are plotted and therefore whether the data are uni-modal or multi-modal. The optimal bandwidth has been automatically calculated by the software for each data sample, although because data densities are quite different the bandwidths for the two samples were, accordingly, different as well. Consequently, I standardised the bandwidths for each pair of plots to be compared, by choosing the smaller width between the two samples. The smaller the bandwidth the more skewed the curve is, and therefore more modes are shown in the plot. This allows identifying different modes even within an apparent uni-modal data sample. This procedure has been conducted for the three Trypillia BI, BII and CI phase, by comparing the KDEs of SBD interfluve sites with the other Trypillia settlements.

The results show the KDE for the BI site in the two samples. The optimal bandwidth for SBD data was 18.73, but it was adjusted to 1.812 in order to compare the two KDE plots. The adjusting factor of 0.09674 already indicates the difference between the modal distributions of the two samples. From the visual inspection of the graph then, it is noticeable how the SBD sample shows a multi-modal KDE as opposed to the bi-modal KDE of the other Trypillia settlements (Fig. 5.11).

[35] http://star-www.st-andrews.ac.uk/cran/ (accessed 25/03/2016).

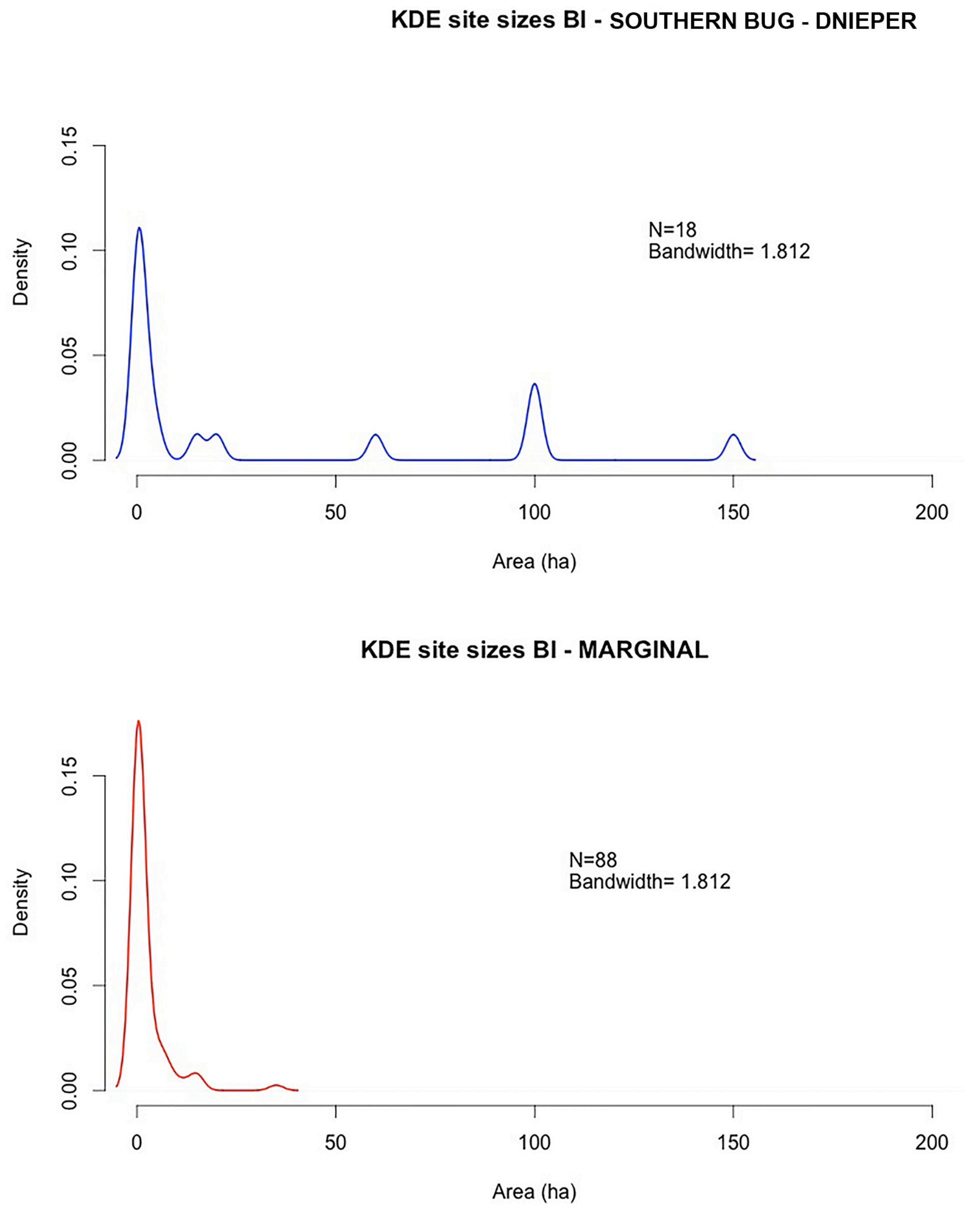
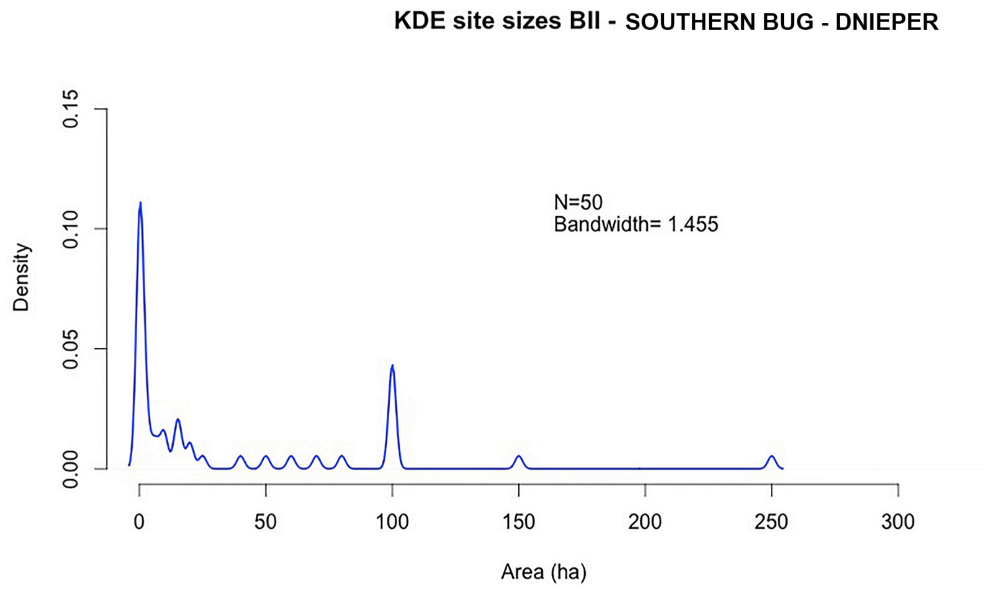


Fig. 5.11. Plot of Kernel Density Estimation of Phase BI site sizes from Southern Bud-Dnieper interfluve and the other territory.



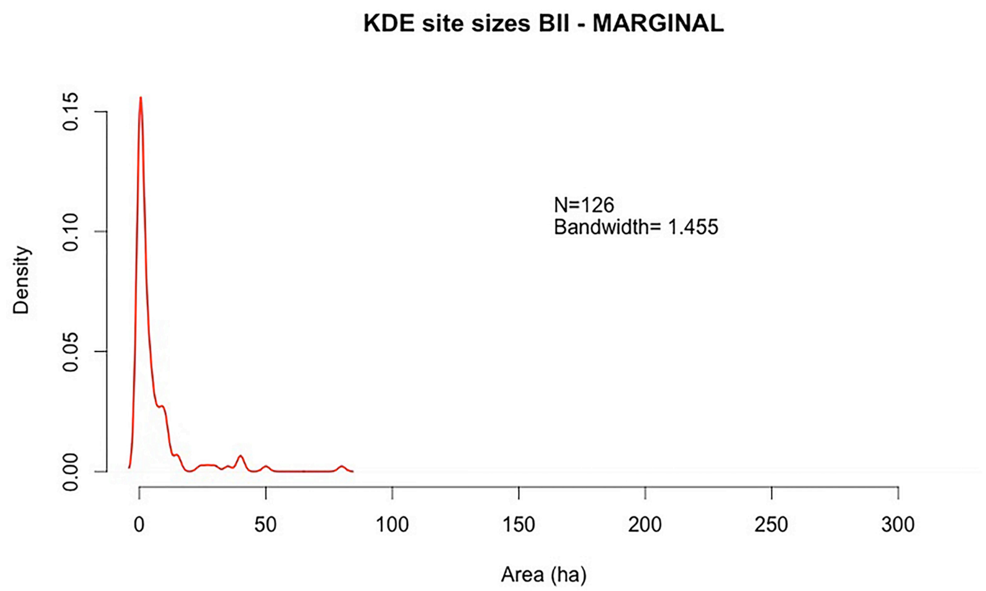
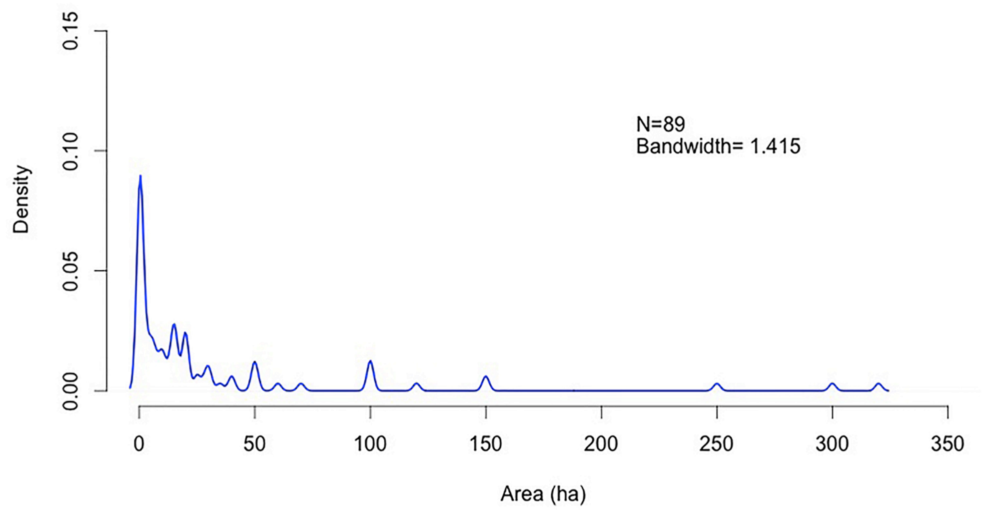


Fig. 5.12. Plot of Kernel Density Estimation of Phase BII site sizes from Southern Bud-Dnieper interfluve and the other territory.

KDE site sizes Phase CI - SOUTHERN BUG - DNIEPER



KDE site sizes Phase CI - MARGINAL

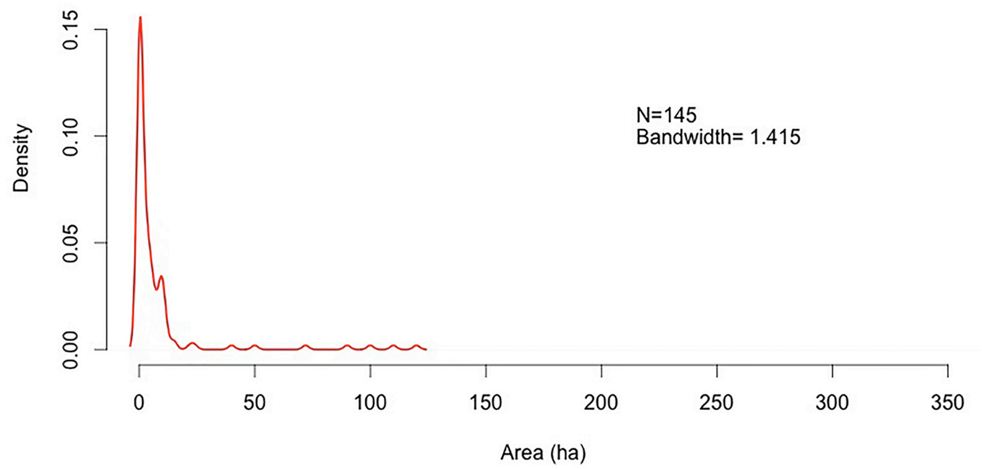


Fig. 5.13. Plot of Kernel Density Estimation of Phase CI site sizes from Southern Bud-Dnieper interfluve and the other territory.

By looking at the comparison between the two sample areas in phase BII and CI, we can observe an increasing difference in the KDE of site sizes, thus suggesting that quite different settlement patterns are developing in the two areas with the appearance and development of the megasites (Fig. 5.12 and 5.13). This difference is also confirmed by the ratios between the optimal bandwidths (BI=0.009674, BII=0.08281, CI=0.18665) of the two samples.

5.5 Spatial distribution of Trypillia settlements: sites clustering and size spatial autocorrelation

Following the exploratory spatial data analysis approach, we can now discuss the distribution patterns of Trypillia sites across the landscape, how they change at different scales and how they changed in time. In order to do that, I approached the data by using two basic principles of point pattern analysis (PPA); namely the analysis of the first and second orders characteristics of a given point pattern (Bailey and Gatrell 1995, 32-35). In brief, the first order characteristics describe the average point density (or intensity) and distribution patterns across the whole region under investigation; whereas the second order characteristics describe the density of points relatively to their internal spatial organization, reflecting internal interactions of attraction of inhibition (Bevan et al. 2013, 31). Understanding the behaviour of data at different scales and their internal interactions provides insightful hints to the archaeologist who has the major challenge of interpreting these patterns, by providing an historical, social, economical, cultural explanatory narrative.

5.5.1 First-order point patterns characteristics: sites clustering

One of the most commonly used analytical tools for studying the overall spatial distribution of point data is the multivariate spatial analysis of clusters. This constitutes the first exploratory step in the analysis of the first order characteristics of a given point dataset, which can be clustered, dispersed or random. Formal cluster analysis (CA) has been proposed by Driver and Kroeber who for the first time applied it in anthropology (Driver and Kroeber 1932). Cluster analysis found many applications in a variety of disciplines as the basis for pattern recognition of an array of different data and information (Kettenring 2006).

As for archaeological applications, CA has found fertile terrain within the study of pottery typology (Hodson 1970) or in general object seriation and classification (Cowgill 1968; Sullivan III and Rozen 1985). More recently, CA has been combined with the chemical signature of different types of ceramics in order to have a better understanding of the production processes (e.g., the Late Neolithic Jomon group in Japan: Hall 2004). With regards to archaeological settlement data analysis, CA has been used for exploring household clustering at the intra-site level for the study of social and economic organization of the Chinese Neolithic at a regional scale (Peterson and Drennan 2005; Peterson and Shelach 2012). Formal CA (such as K-means algorithm[36]) has been conducted on specific datasets such as radiocarbon dates or geochemical signature of soil types and the results have been used as a

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[36] Formal algorithm to quantify the number of clusters (Lloyd 1982).

proxy to define settlement pattern dynamic processes in Australia and South America (Williams et al. 2013; Costa et al. 2013).

As for its application to settlement patterns' analysis, formal CA has been used for the identification of site clusters, although mostly combined with a 'Central Place Theory[37]' theoretical approach, which has been limiting the range of possible archaeological interpretations of the underpinning settlement system (McAndrews et al. 1997). The classic nearest neighbour chain algorithm[38] has been adopted for analysing settlement clusters since the 70s by a number of scholars (Hodder and Hansall 1971; Whallon 1973; Hodder and Orton 1979). The application of this analytical tool to settlement data has been criticised for its scalar limitation (Bevan and Conolly 2006). Archaeologists, in fact, realized that nearest neighbour does not account for the different patterns that can appear if we look at the data at different scales of analysis. Therefore, archaeologists started using a broader range of statistical tools (such as Ripley's K-function and the pair correlation function) in order to pursue a multi-scalar analytical approach, more suitable for understanding the complexity of archaeological settlement data (Bevan and Conolly 2006, 221; Bevan et al. 2013; Ripley 1976; Ripley 1977). Furthermore, the implementation of Monte Carlo simulations (or envelope) in the analyses started increasing their statistical significance (Manly 1991; Bevan et al. 2013, 32-34).

Starting with a simpler visual assessment of the five distribution maps of Trypillia sites one can notice an increasing level of settlement clustering until phase CI – especially with the appearance of the first megasites in phase BI - and a trend to a more dispersed settlement pattern in phase CII (Fig. 5.14). Moreover, by phase BII the full Dniester-Dnieper interfluve is occupied by Trypillia settlements and remarkable further expansions are not visible until phase CII. During phase CI (the period of maximum size of megasites) the level of site clustering reaches its peak, but the areas occupied remain roughly the same. It's only with phase CII, with the end of megasites, that a remarkable overall dispersal can be observed and the Trypillia area of influence reaches its maximum extent.

[37] (Chistaller 1966).

[38] Formal algorithm that suggests whether there are clusters or not in the data distribution – first developed for applications in Ecology (Clark and Evans 1954).

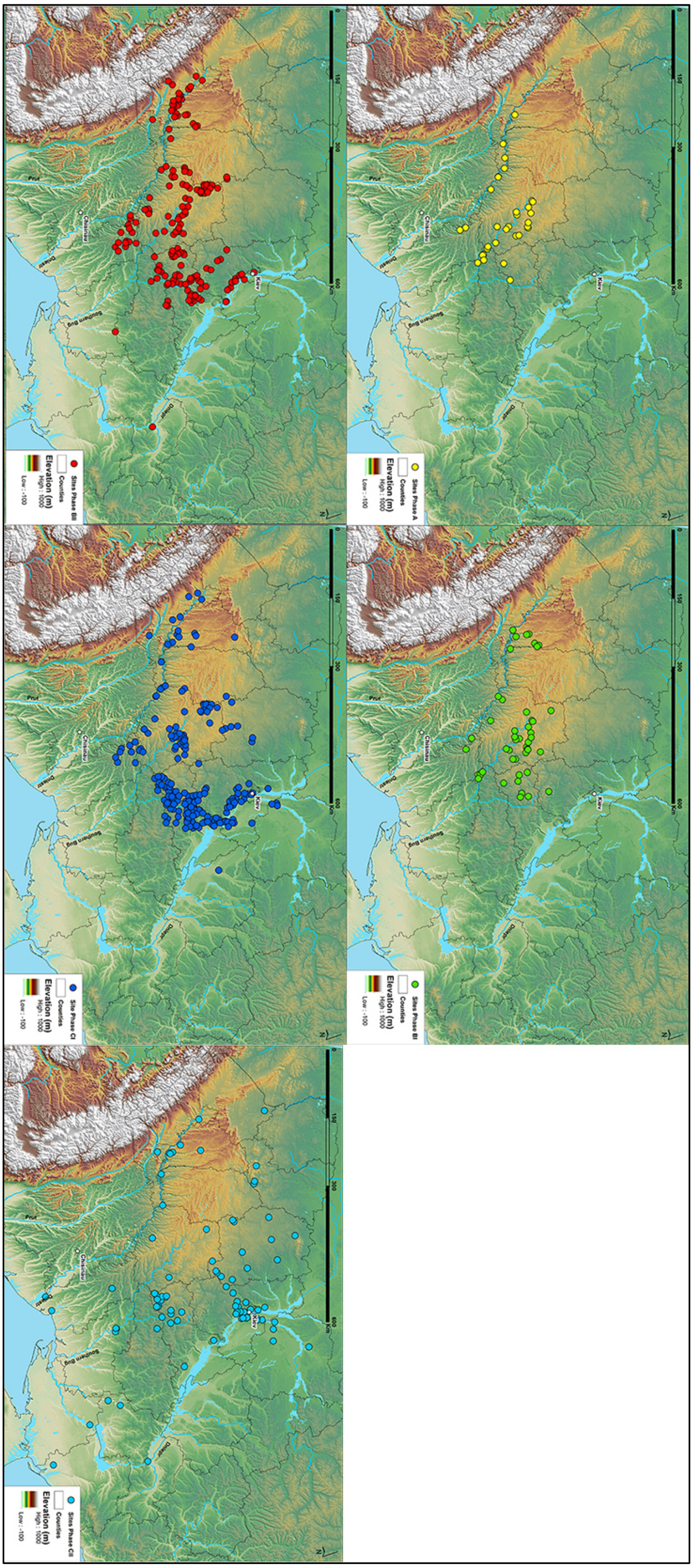

Fig. 5.14. Spatial distribution of Trypillia settlements by phase.

5.5.2 Second-order point patterns characteristics: size spatial correlation

Bearing in mind the development of the overall site patterns throughout the five Trypillia phases, I shall now discuss the internal characteristics of the data and how value size behaves across the landscape. This analysis will provide insightful hints into the scale at which certain phenomena are occurring and will suggest the distance at which we need to look for understanding the range of Trypillia human interactions.

The study of data spatial variability or data spatial autocorrelation found archaeological application since the late 1980s to early 1990s when it was adopted to investigate spatial distributions of tombs (Attwell and Fletcher 1987), settlement locational strategies (Kvamme 1990), the origins and spread of languages (Piazza et al. 1995), or the "collapse" of Classic Maya 'state' (Neiman 1997; Bevan et al. 2013). More recently, it has been applied to smaller-scale analysis of chemical signatures and objects distributions on house floors (Negre et al. 2016; Carrer 2015).

The fundamental tenet underpinning spatial autocorrelation analysis is the so-called Tobler's first law of Geography which states that "***everything is related to everything else, but near things are more related than distant things***" (Tobler 1970). On this basis, the analysis of the spatial dependency of archaeological data and in this case of Trypillia settlement size, could help in understanding the spatial relationship of megasites with other smaller settlements. The statistical analysis is only a tool to describe data patterns; it is then the archaeologist's duty to use the results for interpreting human interactions and the social meaning of these patterns, with the help of the encompassing theoretical framework (see Chapter 6).

5.5.2.1 Global and local Moran's I index

One of the most commonly used methods of analysing spatial autocorrelation of a given value is Moran's I index, developed by Patrick Moran (1950). The index describes the combined behaviour of point location (=site location) and point value (=site size) and whether the pattern is random, clustered or dispersed. The analytical tool is inferential, thus meaning that its interpretation is based on a null hypothesis, which in this case states that the pattern is random. Most software packages[39] calculate the Moran's I value and the z-score and p-value in order to evaluate the statistical significance of the test. Moran's index calculates the global spatial autocorrelation of the data, thus measuring only the overall clustering of a given point

[39] In this research Moran's I test has been performed with ESRI ArcInfo 10.3 package.

dataset. A further development of the test has been suggested by Luc Anselin (1995b), who proposes the “local indicators of spatial association” (LISA) in order to statistically evaluate the clustering occurring in a local spatial unit, starting from the principle that if there is no statistical evidence for global clustering this does not exclude the possibility of local clustering happening. Moreover, Anselin’s local Moran’s I statistics allows for the differentiation of clusters of low and high values and of spatial outliers. In this way it is possible for instance to identify a high value (in this case a big site = megasite) within a neighbourhood of low values (smaller Trypillia settlements) and measure the statistically significant scale of the neighbourhood[40]. In other words, the data will set the scale at which a site becomes statistically ‘mega’ compared to its neighbouring sites.
The important shift from the first-order/global level of point behaviour to the second-order/local level has been already stressed by Premo (2004). While Premo emphasises the importance of local spatial dependence over global ones (Premo 2004, 856) I propose that only the combination of the two scales of analysis can provide useful insight for the interpretation of the settlement patterns, owing to the inter-relationships between local and global domains.

5.5.2.2 Global data patterns (Global Moran’s I)

The first step was to evaluate whether the Trypillia site sizes are clustered, dispersed or randomly distributed in the five different chronological phases.
A Global Moran’s I was calculated for the five samples of Trypillia settlement data to estimate whether the size values were showing clustered patterns or not and whether the presence of megasites in phase Trypillia BI, BII and CI affected the global results (Table 5.3).

Trypillia phase	**Moran’s I**	**z-score**	**p-value**
A	-0.041222	-0.045803	0.963467
BI	0.162981	4.995331	0.000001
BII	0.093793	4.875633	0.000001
CI	0.092319	3.116306	0.001831
CII	-0.001698	0.194523	0.845767

Table 5.3. Results of the Global Moran’s I test on the five samples of Trypillia settlements.

The results show how the null hypothesis of Complete Spatial Randomness (CSR) can be rejected with 95% of confidence for phases BI, BII and CI, which present clustered data patterns. However, for phases A and CII, we can confirm the null

[40] In this Chapter the term ‘neighbourhood’ is used in its spatial statistics meaning of space surrounding a given point or feature.

hypothesis; moreover, the negative z-score would suggest a slight tendency towards a more dispersed spatial distribution.

This set the starting point for the next analysis, more focused on the local spatial dependency of site size values for the three Trypillia phases that returned a clustered behaviour at a global scale - phases corresponding to the appearance and development of megasites. As a general remark, we can confirm that the introduction of megasites did correspond with a global settlement nucleation.

5.5.2.3 Setting the scale of clustering. Incremental Global Moran's I

The next step is to evaluate at what scale the phase BI, BII and CI data show a clustered behaviour, thus statistically defining the clusters' neighbourhoods. In order to do so, a number of incremental global Moran's I have been calculated at different distances with equal intervals for the three samples, starting from an initial distance band based on the 2nd nearest neighbour count, for 30 iterations each. The results of the test are displayed in Fig. 5.15-17 and show the z-scores at each calculated distance. The peak distances at which the cluster is more statistically significant are highlighted with a cyan dot; a summary of the results is shown in Table 5.4.

Trypillia phase	**Initial distance (km)**	**Increment distance (km)**	**z-score**	**Peak distance (km)**
BI	52.504	2.067	4.256878	83.516
BII	31.619	4.215	9.967631	111.721
CI	97.638	1.354	4.650445	98.992

Table 5.4. Summary of the incremental global Moran's I for the three data samples that returned a clustered behaviour after the first global Moran's I test.

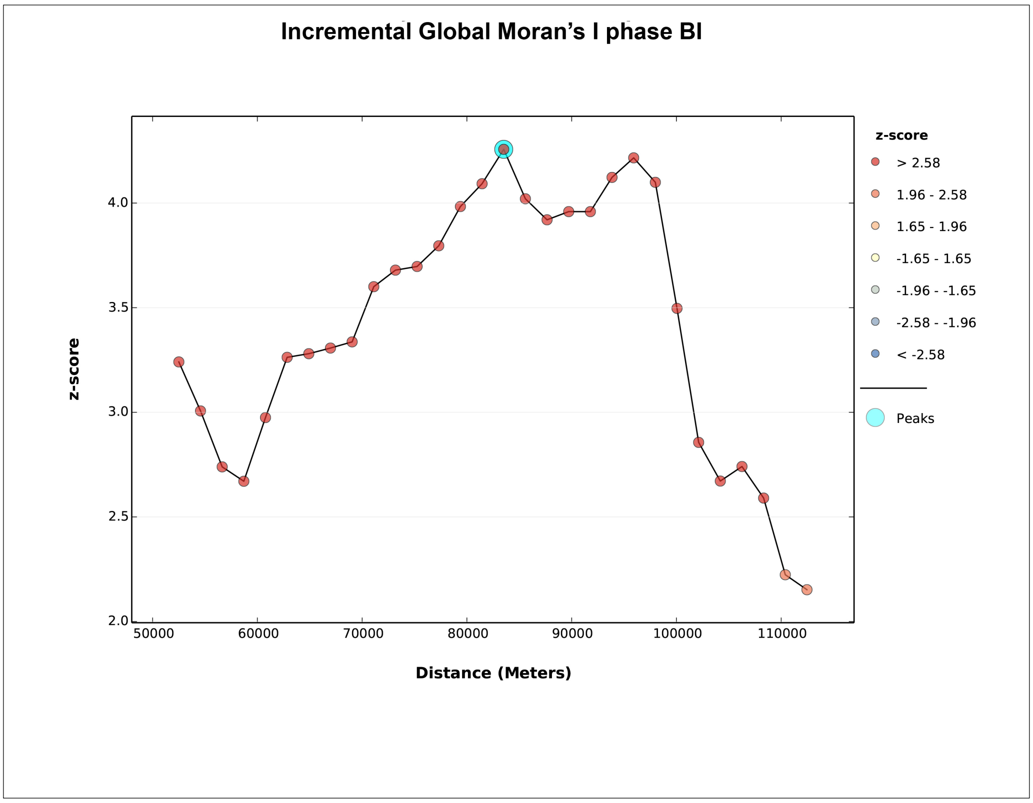

Fig. 5.15. Incremental global Moran's I test results, Phase BI data sample.

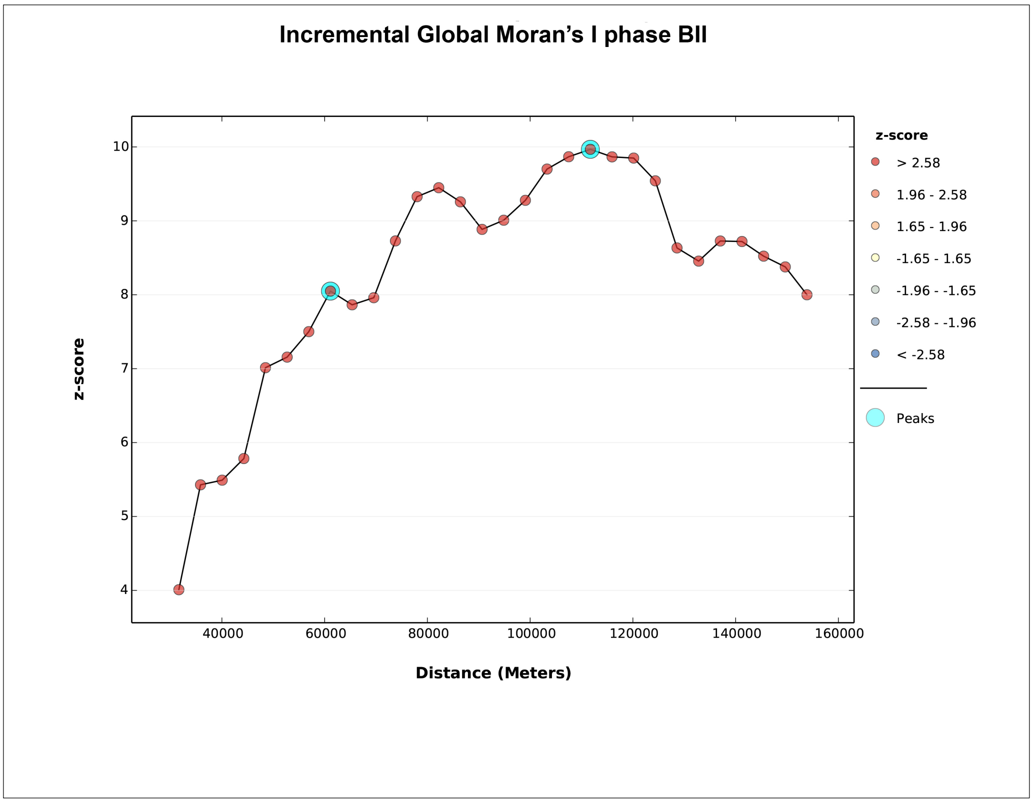

Fig. 5.16. Incremental global Moran's I test results, phase BII data sample.

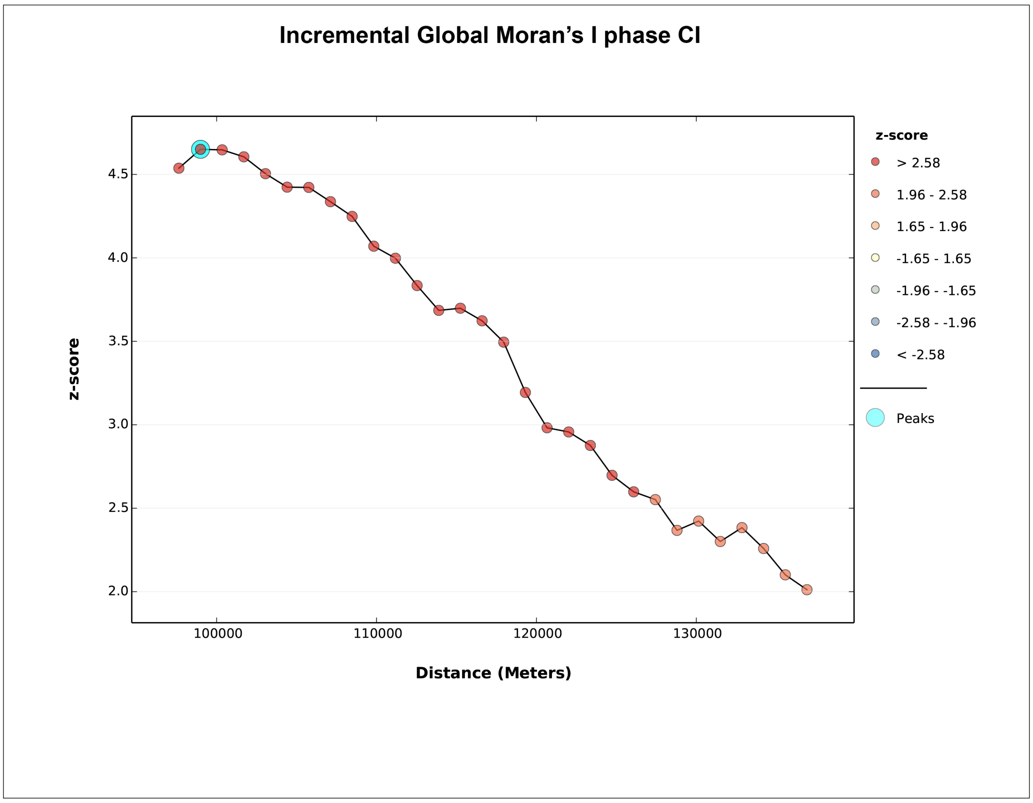

Fig. 5.17. Incremental global Moran's I test results, phase CI data sample.

The results indicate that the optimal distance at which the data show a clustered behaviour is around 100 km for each phase but different levels of clustering are suggested by z-scores. Considering the difference in number of sites and megasites (see Fig. 5.10) in each phase, the almost consistent optimal distance acquires an even higher significance as a common pattern between the three phases that cover almost 1,000 years. We can, therefore, argue that ~ 100 km has a statistical significance in terms of settlement pattern nucleation and will be used in the next set of analyses aimed at showing where these clusters are and how they behave in the presence of megasites.

5.5.2.4 Local data patterns (Anselin Local Moran's I)

The local Moran's I test proposed by Luc Anselin (Anselin 1995) aims at identifying clusters of high values, low values and outliers, within a defined neighbourhood. Depending on z-score and p-values, a point can be defined as part of a cluster of high values or a cluster of low values or an outlier. Positive z-scores indicate that the point is part of a high or low values cluster, negative z-scores indicate that the point is an outlier, meaning that it is surrounded (within the neighbourhood) by points with dissimilar values. A pair of z-score and p-values is calculated for every point, thus meaning that for each site it is possible to assign a probabilistic value of the site being part of a cluster or being an outlier. For this analysis, the Cluster and Outliers Analysis (Anselin Local Moran's I) tool included in ESRI ArcInfo Desktop 10.3 has been used (Mitchell 2005). The tool group creates, as an output, a table with Moran's I values, z-score values and p-values for each point, permitting the assignation to a type of cluster or outlier to each point with a statistically significant p-value (< 0.05). The type field indicates whether a point is part of a cluster of high values – big sites – (HH), or part of a cluster of low values – small sites – (LL), or a high value outlier surrounded by low values – big site surrounded by small sites - (HL), or a low value outlier surrounded by high values – small site surrounded by big sites - (LH) within a set neighbourhood.

Based on site size, a local Moran's I statistic has been calculated for each of the three data samples that showed a global degree of clustering (BI, BII, CI), using a neighbourhood distance[41] set by the incremental global Moran's I test. If we make a graphic comparison of the results[42] of the test with the locations of the megasites (yellow dots), it is clear how the two global settlement patterns, described in section 5.3, are confirmed to be statistically significant also within smaller neighbourhoods (~ 100 km) for all the three Trypillia phases. In fact the SBD interfluve appears to be a mega-cluster of high values (black dots – HH), whereas the rest of the territory is characterized by the presence of spatial outliers with high values surrounded by low values (red dots – HL) (Fig. 5.18-19-20). This reinforces the argument that the way the data are behaving in the SBD interfluve is significantly different from that of the rest of the areas.

Diachronically, we can observe that despite the overall increasing number of sites, the mega-cluster seems to be established as a distinctive point pattern, as early as phase BI - the appearance of the first megasites. Conversely, outside the SBD interfluves, point patterns seem to change throughout the three phases. In phase BI (Fig. 5.18) the ***mega-cluster*** is already 'formed' by the four megasites (Vesely Kut, Vilkhovets II, Karkivka and Baghashivka II), which correspond to HH points (black dots). But outside the SBD interfluve there are no significant point patterns in the spatial distribution of site sizes.

In phase BII (Fig. 5.19) the mega-cluster expands towards the Dnieper basin and a number of LH outliers (green dots) start to appear in the same area. This indicates the development of smaller sites, alongside the increasing number of megasites, within the area of the SBD interfluve. Outside the SBD basin one site (Kurylivka = 50 ha) appears to be a statistically big site surrounded by smaller settlements, thus configuring as a HL outlier (red dots). This suggests that in the apparently "marginal" areas there is evidence of the development of a statistically significant difference in site sizes alongside a global increasing level of settlement clustering (Fig. 5.14). This

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[41] Neighborhoods' distances have been rounded to the next integer value (phase BI = 83.516 km → 84 km; phase BII = 111.721 km → 112 km; phase CI = 98.992 km → 100 km).
[42] See appendix C for the table with local Moran's I results.

difference, though, is significant only at a certain scale[43] (~ 100 km), thus meaning that locally the nucleation of settlements is not corresponding to the development of site size hierarchies.

[43] Local Moran's I tests have been calculated for smaller neighborhoods, but the HL outlier is emerging only at a distance of 111.721 km.

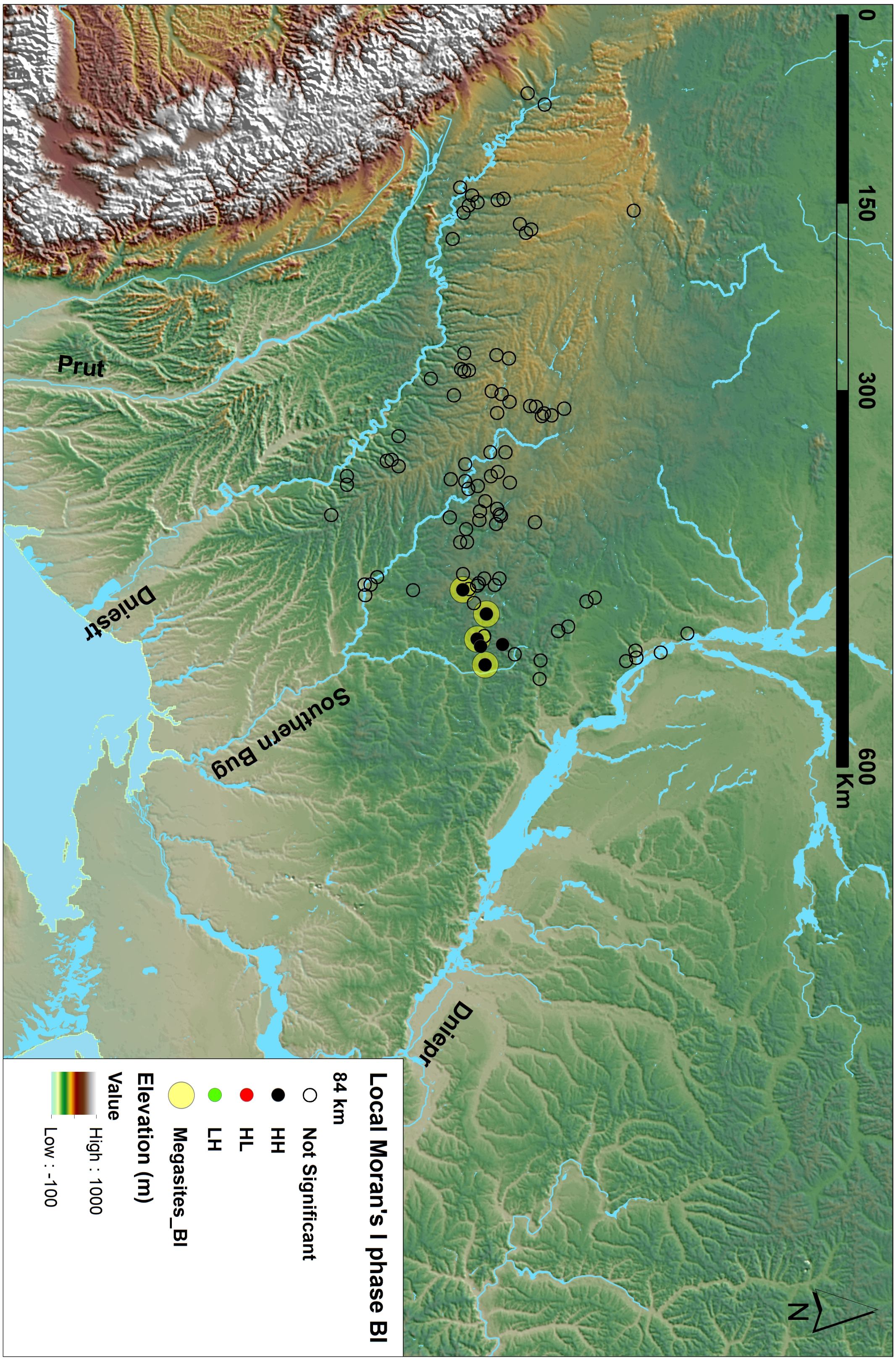

Fig. 5.18. Local Moran's I calculated for Trypillia BI sites with a neighbourhood distance of 84 km.

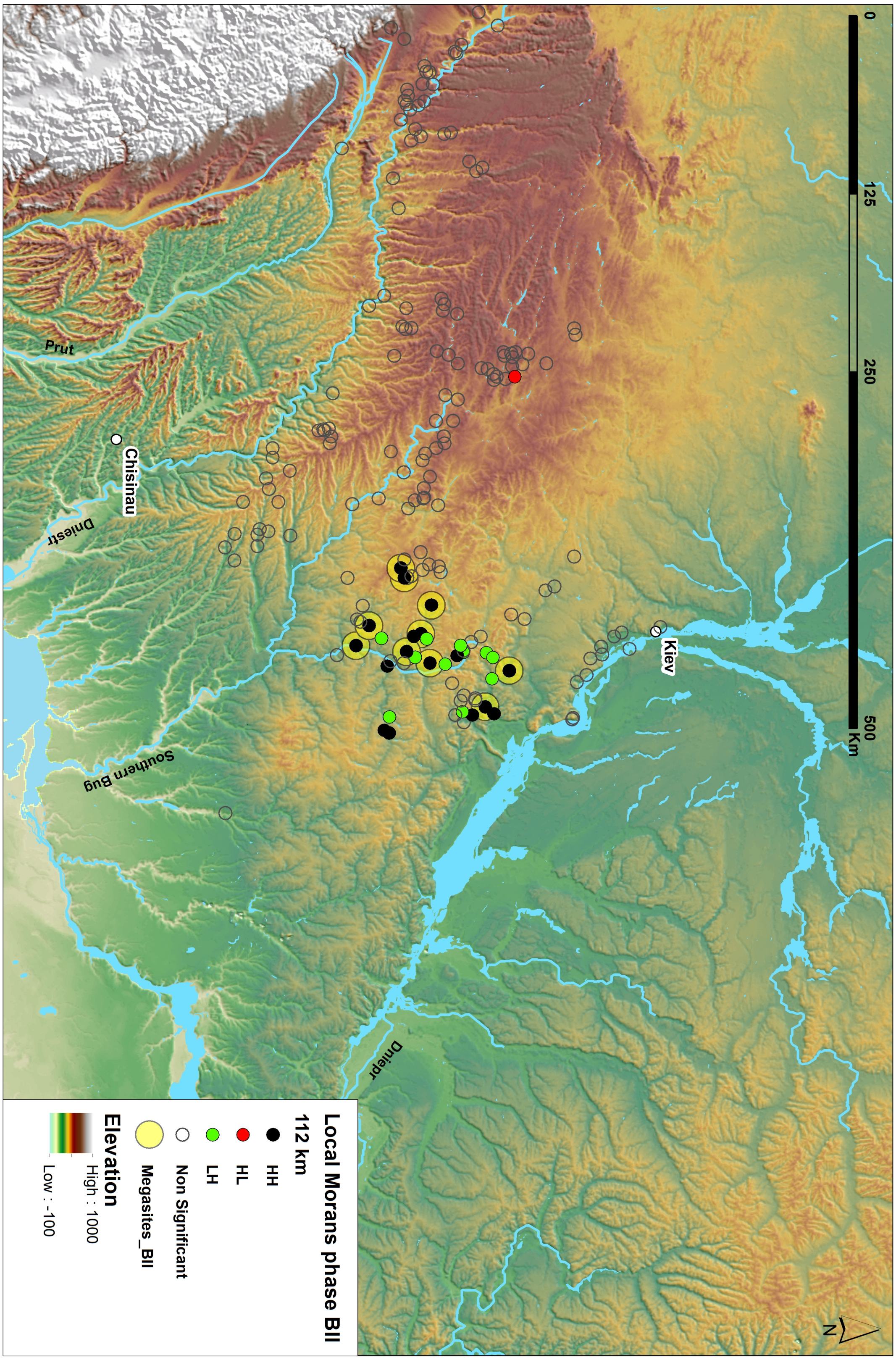

Fig. 5.19. Local Moran's I calculated for Trypillia BII sites with a neighbourhood distance of 112 km.

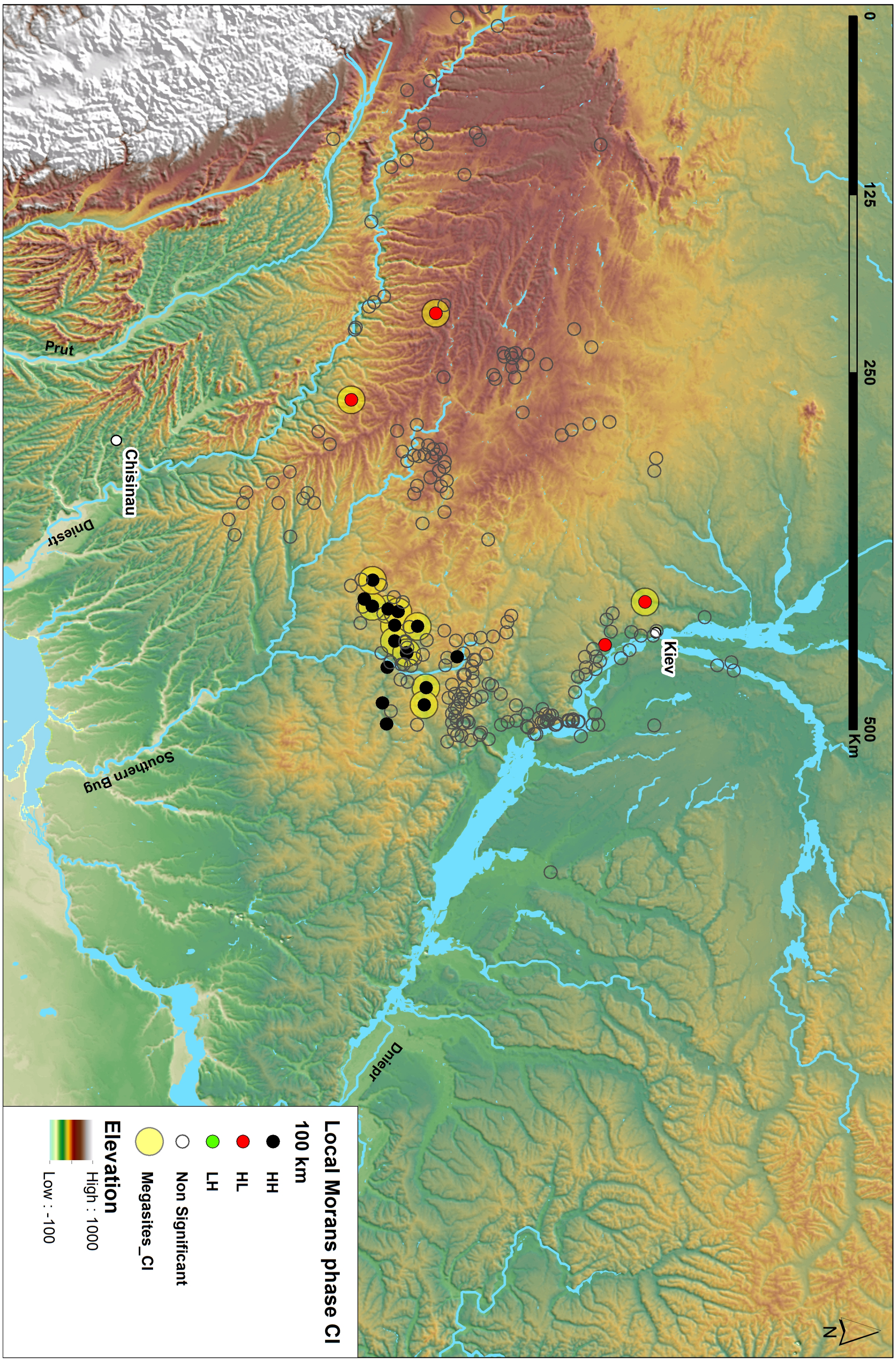

Fig. 5.20. Local Moran's I calculated for Trypillia CI sites with a neighbourhood distance of 100 km.

In phase CI (Fig. 5.20), there is a reduction in extent of the mega-cluster with the disappearance of LH outliers, probably due to the increasing number of megasites and increase in their size. This would shrink the number of point part of the cluster, as a smaller number of bigger sites closer to each other would appear a cluster of high values statistically different from the surrounding sites. In fact, the mean value of megasites' sizes for the three phases increases (BI = 112.5; BII = 120; CI = 155). This confirms the increasing total of megasites in the SBD interfluve, alongside a stationary number of smaller sites in the same area.

Outside the mega-cluster, alongside with the progressive expansion and nucleation of Trypillia settlements (Fig. 5.14) at the global scale, the appearance of a number of HL outliers corresponding to 'isolated' megasites suggests the development of a quite definite settlement pattern, where megasites emerge as high-value spatial outliers of low-value clusters only within a neighbourhood distance of 100 km.

The settlement pattern, finally developed in phase CI outside the mega-cluster, suggests that the definition of a megasite as a settlement with a size of 100 ha or more and with a characteristic layout discussed in section 5.3 needs to be integrated with the spatial relationship that these big sites have with the rest of smaller settlements. The early development of the SBD cluster of megasites (HH) goes along with the emergence of a settlement pattern outside the ***mega-cluster***, where similar megasites become statistically bigger than the rest of the settlements only at a quite large scale of ~ 100 km.

This statistical scale of emerging megasites could suggest the human scale at which these settlements were seen as exceptionally big and therefore "special" places, but I will discuss the social implications of this scalar threshold in Chapter 6. In the next section, we will discuss more closely the immediate hinterlands of the megasites, both within the SBD interfluve and in the other areas. Moving to a smaller scale of analysis will provide further insights that will be then drawn together with the other pieces of evidence in an encompassing archaeological explanation.

5.6 Megasites' micro-hinterlands

Archaeologists have been discussing the concept of 'hinterland' especially in relation to the concept of 'city' and 'urban formation', and providing a number of different definitions of 'hinterland' depending on the scale they were talking about (Johnson 1982; Falconer and Savage 1995; Liu 1996; Bintliff 1997; Kusimba and Kusimba 2000; Bintliff 2000; Buteux et al. 2000; Algaze 2001; Juma 2004; Bintliff et al. 2007; Nekhrizov et al. 2012; Redmond and Spencer 2012; Mattingly and Sterry 2013; Wilkinson et al. 2014; Smith 2014; Smith 2015; Lawrence and Wilkinson 2015; Whitelaw 2013; Gaydarska 2016). Different scales mean different types of hinterlands, ranging from an immediate hinterland devoted to agro-pastoral activities in support of the main site or regional hinterlands formed by satellite settlements, which have a socio-economic relationship with main site. While both immediate and regional hinterlands are archaeologically detectable (Bintliff and Snodgrass 1988), only the immediate hinterland can be more accurately defined (Wilkinson 1982) because the definition of the regional hinterland is affected by the sample size of the survey and the sampling strategy of the survey (Dunnell and Dancey 1983; Gallant 1986; Wilkinson 2000).
Both forms of hinterland have been crucial in the understanding of the formation processes and sustainability of sites of a certain size, and considered one of the fundamental characteristics of the Childean definition of the 'urban' (Childe 1950).

Whilst so far we have discussed the great informative potential of investigating the broader regional hinterland of megasites, now we will focus on the immediate ***near-site*** hinterland of one of the megasites - Nebelivka - that has been the focus of the ***Trypillia Mega-Sites*** project.

The reason for investigation of the immediate hinterland of such massive and dense settlements is that of site sustainability. Namely, if we argue for a large coeval population living in mega-sites (e.g. Rassmann et al. 2014; Müller et al 2016), they would have exploited the surrounding territory for a number of economic activities. Several scholars have studied the Trypillian economy (Bibikov 1965; Gaydarska 2003; Harper 2011; Nikolova and Pashkevich 2003; Pashkevych 2012; Shukurov et al. 2015; Ohlrau et al. 2016) and all the models propose an agro-pastoral mixed economy based on archaeological evidence. Carrying capacity models, however, propose that in order for such massive sites to be sustained by land products, even in a mixed economy, they needed the help of manuring and ard tillage (Shukurov et al. 2015, 280). Ethnographic data suggests that the maximal limit of arable land around a site stays within 1.5-2 hours of walking distance (Jarman et al. 1982, 30-31), which translates to approximately 5 km in terrains like the Ukrainian steppe. This distance is also the estimate proposed for infields and outfields extent around Bronze Age tell sites in Mesopotamia (Widell et al. 2013). The most recent carrying capacity model developed by (Ohlrau et al. 2016) also proposes a minimal radius of approximately 5 km for arable land around megasites like Maidanetske and Taljanki (respectively 200 and 320 ha). All the models recently developed are based on the contemporaneous occupation of the majority of the dwellings in the megasites (Ohlrau et al. 2016, Table 5; Shukorov et al. 2015, 239-240), thus relying on a maximalist population estimation for each site. Shukorov et al. (2015) argue that even a fertile soil like the Chernozem needs manuring and ard tillage for supporting the agricultural regime needed to supply even small sites (10-20 ha).

Therefore, the investigation of the immediate (~ 5 km) hinterland of Nebelivka has been conducted in order to check any archaeological evidence of farming activities and more specifically, manuring practices. Evidence of manuring has been identified in scatters of worn potsherds spread on the fields as part of debris coming from the settlement (Bowen 1962, 6; Wilkinson 1982; Wilkinson 1989; Gaffney, Gaffney, and Tingle 1985; Bintliff and Snodgrass 1988; Alcock and Cherry 2004; Chapman et al. 2010a).

The first systematic field survey ever conducted in Ukraine has been carried out in the near hinterland of the site of Nebelivka (Trypillia BII), covering around the 42% of the available fields (Fig. 5.21[44]). During season 2013 we adopted a non-site sampling strategy (Thomas 1975) in order to assess the definition of 'site' derived from surface material. This involved picking up and positioning every single small find with an accuracy of 3 metres. The results show four major surface scatters, which can be identified as archaeological sites (Fig. 5.22) among a huge quantity of ***off-site*** material. Of approximately 1,000 potsherds collected in 30 sq. km., only 1 can be reported as dating to the Trypillia period.

[44] See also chapter four for the methodological details of the survey.

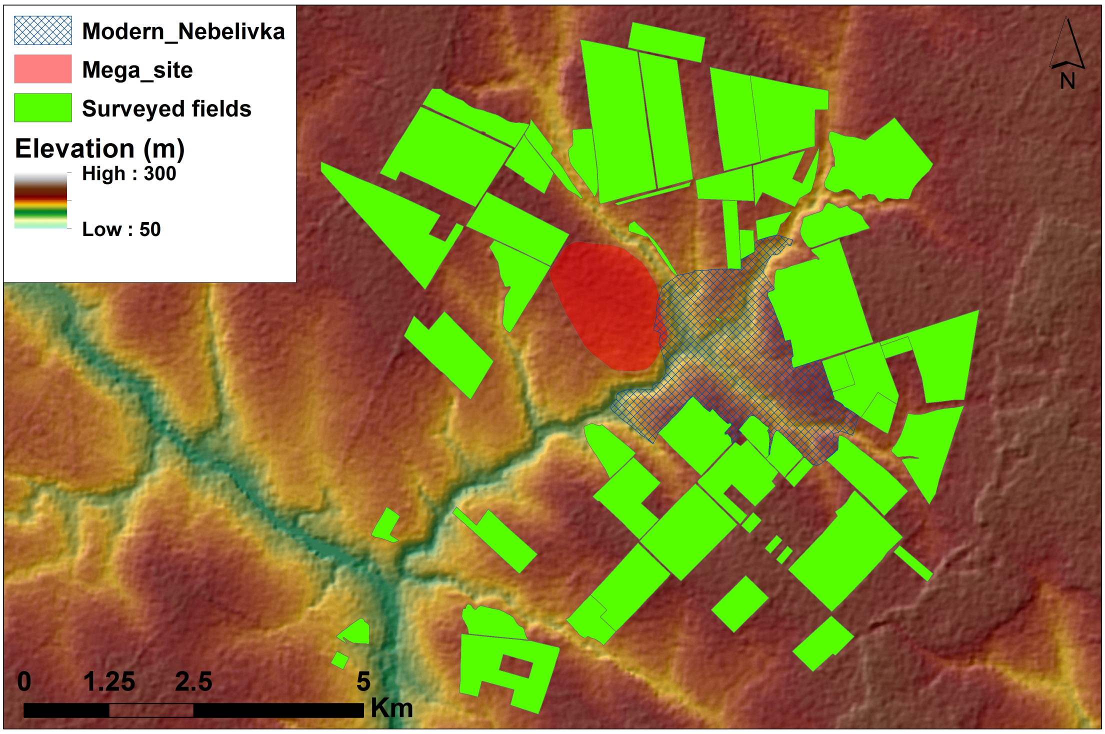

Fig. 5.21. Available fields surveyed, 5 km radius of Nebelivka (phase BII).

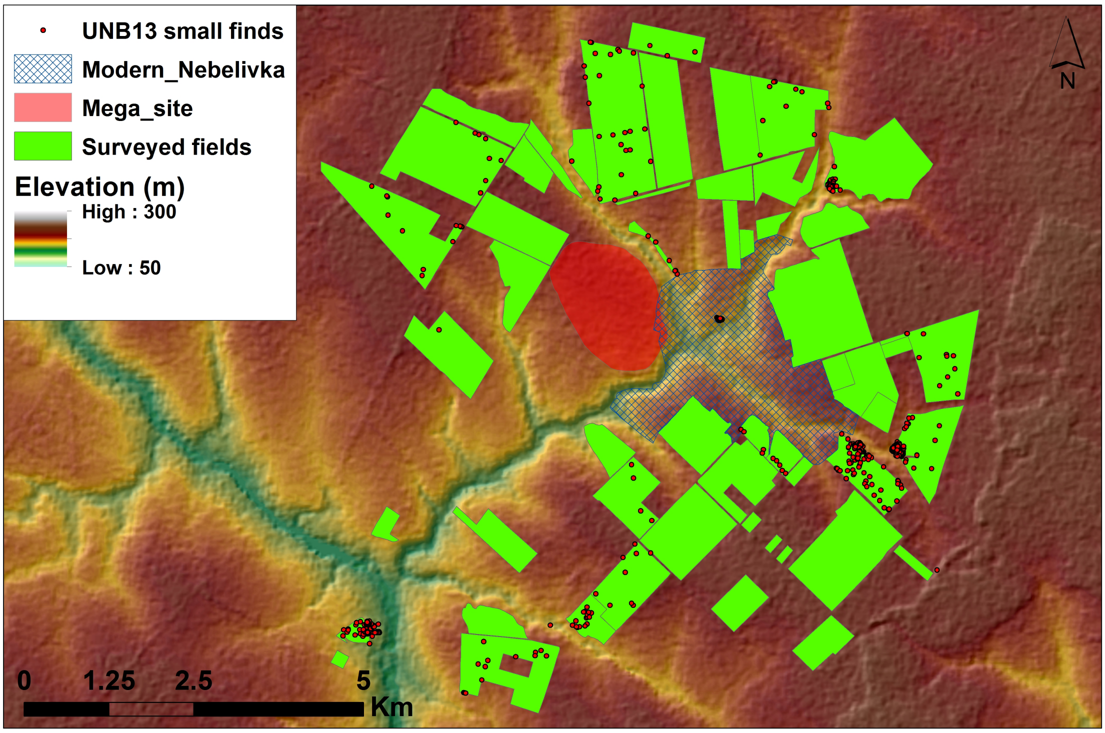

Fig. 5.22. Surveyed fields around Nebelivka (phase BII) and the results of the non-site sampling strategy adopted in 2013 to assess the definition of 'sites' from surface scatters.

The results of the field survey show that there is very little, if any, archaeological material presence in the immediate surroundings of a 236 ha settlement with almost 1,500 dwellings. Therefore, it can be argued that this is negative evidence for such intensive land exploitation as proposed by the carrying capacities models developed by Ohlrau et al. (2016) and Shukorov et al. (2015).

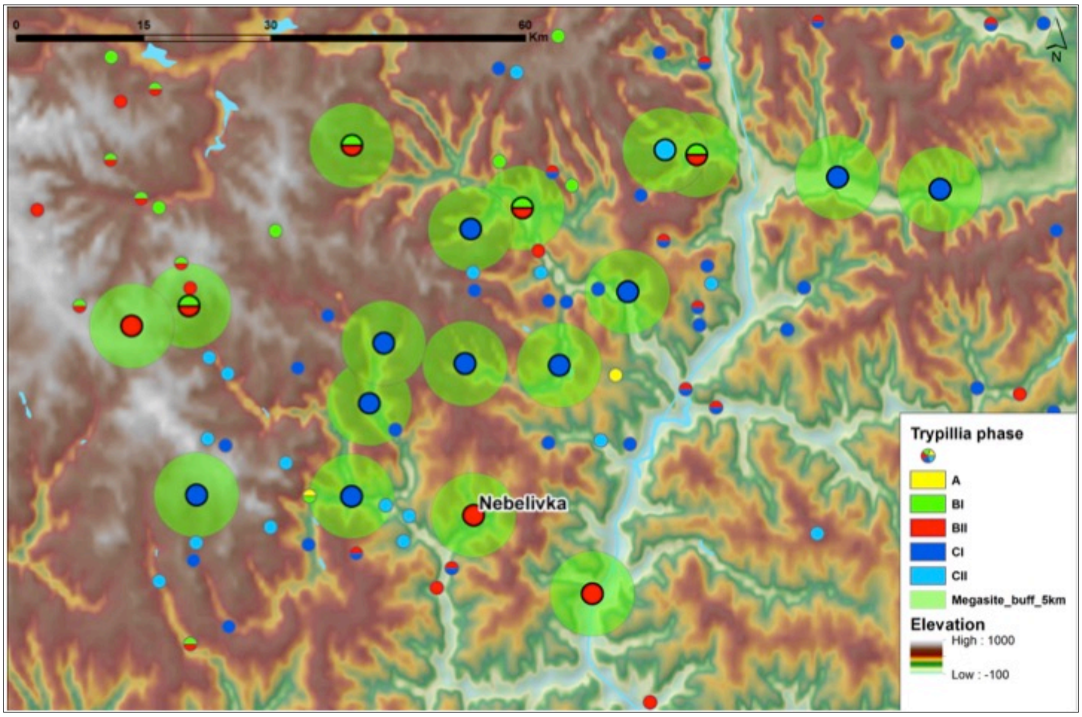

Fig. 5.23. 5-km hinterlands of megasites in the Southern Bug-Dnieper interfluve.

Looking at the immediate hinterlands of the other megasites in the SBD interfluve, it is noticeable how the absence of other coeval sites is a common characteristic for phases BI, BII and CI. This could suggest that those territories were devoted to farming, although the in-depth survey of the Nebelivka micro-region seems to contradict this hypothesis. More systematic field survey around megasites would help understanding whether this is an isolated pattern or a common trait for these big settlements. As for Nebelivka, further evidence demonstrating a very small impact of the settlement on the local environment derives from the results of the pollen sequence obtained by a core located 250 m Northeast of the edge of the megasite at the bottom of the river valley (Fig. 5.24). The results show how, during the occupation of the settlement, the quantities of cereals are even lower than during either the pre or post-occupation period of the Nebelivka (Albert et al., submitted).

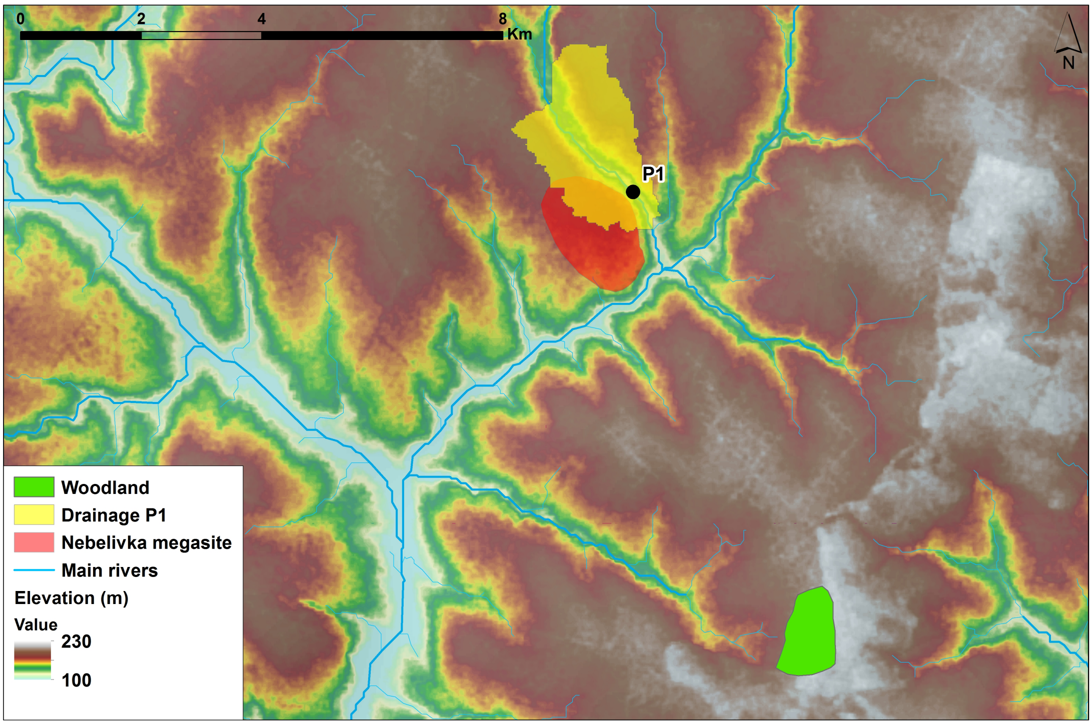

Fig. 5.24. Location of the Nebelivka P1 pollen core.[45]

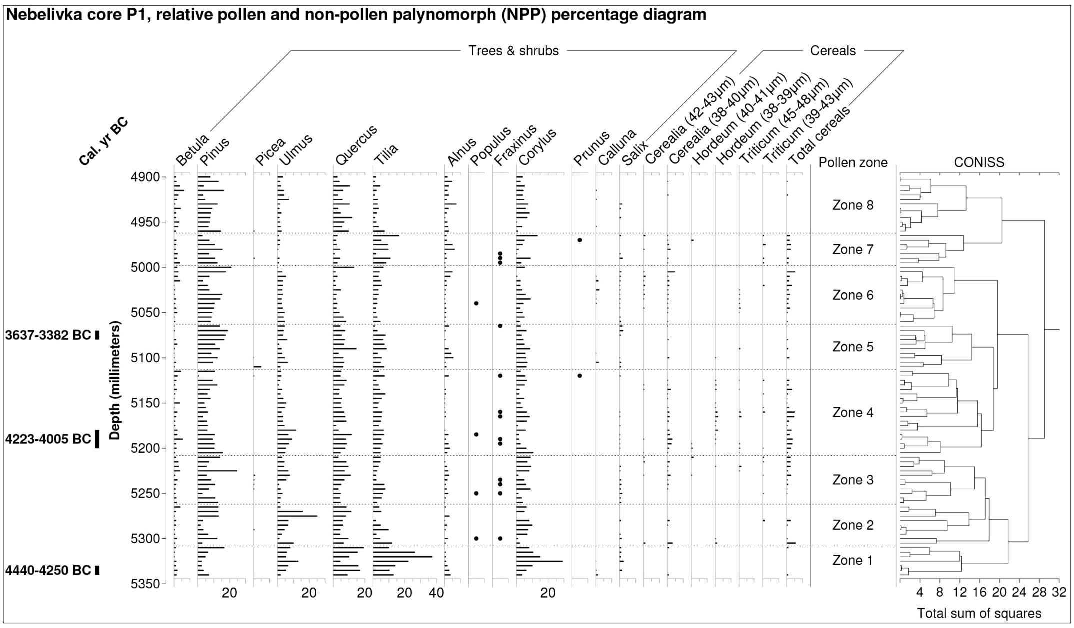

Fig. 5.25. Pollen analysis results, Nebelivka P1 core.

I am not going to discuss the full details of the pollen sequence analysis, but I am here only taking for the purpose of my argumentation the overall results of the megasite's minimal human impact on the local environment. Combined with the absence of archaeological evidence for manuring, these results would stand against a permanent, coeval occupation of large parts or even the entirety of the megasite.

[45] The complete results of the pollen sequence are being currently published (Albert et al. in prep).

Only more data derived from further systematic field-walking around other megasites combined with more pollen analysis conducted on core locations nearby megasites as well as smaller sites could confirm or reject this pattern. The two models developed by Ohlrau et al. (2016) and Shukorov et al (2015) assume that the single megasite or smaller settlement is entirely occupied at the same time, but this is a 'mega-assumption' since no-one yet has a fine-grained chronological sequence of the dwellings' development. Most of the arguments in favour of the coeval occupation of all the dwellings derive from the assumption that the formal layout of these settlements (including the whole range of archaeological features such as, kilns, mega-structures, and houses' rows) has to be developed by a single top-down decision making process (Müller et al. 2016). Notwithstanding, other possibilities to explain the formation processes of such structured layouts can be included in the discussion, if the megasites are considered in the broader context of the rest of Trypillia settlements. The extraordinary dimension and density of megasites cannot be really appreciated if we do not include their relative capacity for accommodating people coming from coeval smaller settlement.

We shall now propose several interpretational alternatives, working outwards from the results of formal analysis already discussed.

5.7 Megasites' relative capacity: how many people could fit in a megasite at any one time?

As inaccurate as it can be, population estimates can be useful for the understanding of settlement patterns and human-environment interactions.

In this research, this sort of approximation has been used to investigate potential interactions between megasites and smaller coeval settlements. Despite the low-quality data, the estimate of a megasite population at any one time could provide insights for further explanations of the function of such big settlements.

Considering the coeval regional hinterland of Trypillia settlements, how many people could congregate on a single megasite from the surrounding territory?

In order to answer this question, we need to delimit the "surrounding territory", thus defining the comparative context for population estimates. This can be set starting from the neighbourhood distance of 100 km derived from the cluster analysis (see section 5.5.2.4) - the scale at which megasites become statistically significant outliers and therefore exceptionally bigger than the other settlements.

The second and equally important factor to set is to define what information to use as a proxy for population estimate. The study of population estimates has a long history in archaeology, with the concomitant development of a number of analytical tools (Baker and Danders 1972; Hassan 1978; Schacht 1981; Brown 1987; Bocquet-Appel et al. 2005; Bocquet-Appel and Bar-Yosef 2008; Porcic 2010; Porčić and Nikolić

2015). Among the different proxies used for demographical analysis, the household floor area has become the most commonly used in recent years (Chamberlain 2006; Casselberry 198?; Hassan 1981; Brown 1987; Porčić 2011). The method starts from using mean interior floor size for estimating the number of people living in one house (Brown 1987) and multiplying this, by the number of houses in a given site.
The main problem with this method is that overestimations are frequent when houses are not occupied at the same time (Cameron 1990; Porčić 2011). This raises the issue that questions like "what is the population size of a given settlement?" needs to be amended to "what is the initial population?" or what is the final population size?" (Porčić and Nikolić 2015). Cameron (1990) and Porčić (2011; 2015) addressed these questions by including in the population size estimation a growth rate based on archaeological data. Cameron (1990) introduce a fixed growth rate in the model (which inaccurately represented real life), Porčić (2011) attemped to integrate the population growth with the house accumulation model but only more recently he included the Bayesian component in the modelling of the site growth of Lepenski Vir during the Mesolithic-Neolithic transition (2015).

However, none of these case studies considers the possibility of a seasonal occupation of the sites in the population growth models. More complex social and political dynamics might have occurred in a seasonal settlement and vaster areas could have been occupied at the same time without the need of a strongly structured organizational hierarchy, for instance.
So far, from the data collected across Trypillia megasites, we do not have enough evidence to assume that all the dwellings were in use at the same time, despite their structured spatial distribution. Moreover, we are also lacking the evidence of a substantial impact on the local enviroment, which suggests a smaller human footprint. Consequently, we could start thinking of a seasonal use of parts of the megasite, thus meaning a population estimation based on a partial occupation of the whole number of dwellings. This complicates the model, but support could be derived from the relative capacity of megasites compared to the smaller settlemements, thus raising the question of "How many smaller settlements could fit in a megasite at any one time?".

This new seasonal perspective has never been included in the recent history of population estimations of Cucuteni-Trypillia culture (Preoteasa 2009; Diachenko 2013; Videiko 2013; Diachenko 2016).

It is rather difficult to model the seasonal demography of a settlement relying on the intra-site data only. Therefore, starting from the neighbour settlement data could help providing a starting position. In the case of Trypillia BI, BII and CI phases the statistical neighbourhoods of megasites have been defined as a catchment of ~ 100 km radius; hence the question is how many sites from the neighbourhood could fit in a megasite?

The proxy element considered for population estimates' comparisons is the estimated number of dwellings. The assumption that the same household unit would have accommodated the same number of people both on small sites and on megasites overcomes the vexed ***question*** of Trypillia houses being one or two-storey (Kruts 1990; Shumova and Ryzhov 2003; Videiko 2005; Chernovol 2012; Kolesnikov 2013). Nonetheless, the problem remains of whether the smaller sites and the megasites had the same forms of dwellings.

For the majority of the sites in the database, information regarding the extent of the surface scatters of archaeological material is provided (see Chapter 4 for discussion of these data). Therefore, the estimation of the number of dwellings derives from the dwelling density. There has been an improvement since the publication of geophysical plans of Trypillia sites at the beginning of the 2000's (Koshelev 2005). However, it is hard to distinguish between the different intra-site feature types on Koshelev's plans, meaning that using those data would result in an overestimation of the number of dwellings in a given site (Fig. 5.26). More recent geophysical surveys brought a nuanced input into the intra-site structural organization, by first showing that there are a number of unburnt dwellings (which were never mapped before) and a number of other features like kilns or ovens that produced anomalies easily mistaken for houses (Chapman et al. 2014; Rassmann et al. 2014).

Consequently, for the estimate of dwelling densities, I relied only on the new geomagnetic plans, which unfortunately include only one non-megasite, the CI settlement of Apoljanka (Rassmann et al. 2014, Fig. 36). As for the dwelling density of the megasites, the results of the latest geophysical plans are reported in Table 5.5.

Fig. 5.26. Geomagnetic plan of Trypillia megasite of Glybochok (Uman region) derived from Dudkin's surveys from 1971 to 1974 (Koshelev 2005).

Megasite	Area (ha)	No of dwellings/ha
Taljanki	320	6.26
Nebelivka	236	5.79
Maidanestske	250	11.8
Dobrodovy	150	12.1

Table 5.5. Areas and dwelling densities for the megasites in the SBD interfluve for which we have new geophysical plans (after Chapman et al. 2014; Rassmann et al. 2014).

The variability of dwelling density across the four megasites is not correlated to site size; moreover, only for Nebelivka do we have a complete plan of the settlement

(Chapman et al. 2014). Therefore, I used the dwelling density of Nebelivka as a conservative proxy for the estimation of house numbers for all the other megasites for which we do not have a modern geophysical plan. As for smaller settlements, the estimates of house numbers were computed from the density of 1.63 (dwellings/ha) calculated for the site of Apoljanka.

Despite the cumulative errors due to the number of issues with data accuracy and reliability discussed, a very general overview of the megasites potential to accommodate a large number of smaller sites is here proposed.

5.7.1 The population capacity of 'isolated' megasites

For this comparison Phase CI has been chosen as an example for the 'isolated' megasites because it is only in this phase that we see the development of structured settlement patterns outside the ***mega-cluster***.

If we consider, for instance, the 'isolated' CI megasites of Stina (100 ha), Yaltushkiv I (110 ha), Bilohorodka (120 ha) and Obulkhiv (90 ha), and their 100 km neighbourhoods, we can see a clear pattern of empty immediate hinterlands and clusters of settlements forming at a substantial distance of approx. 100 km from the megasites (Fig. 5.27). The clusters of settlements are derived from the Local Moran's I test discussed in section 5.5.2.4.

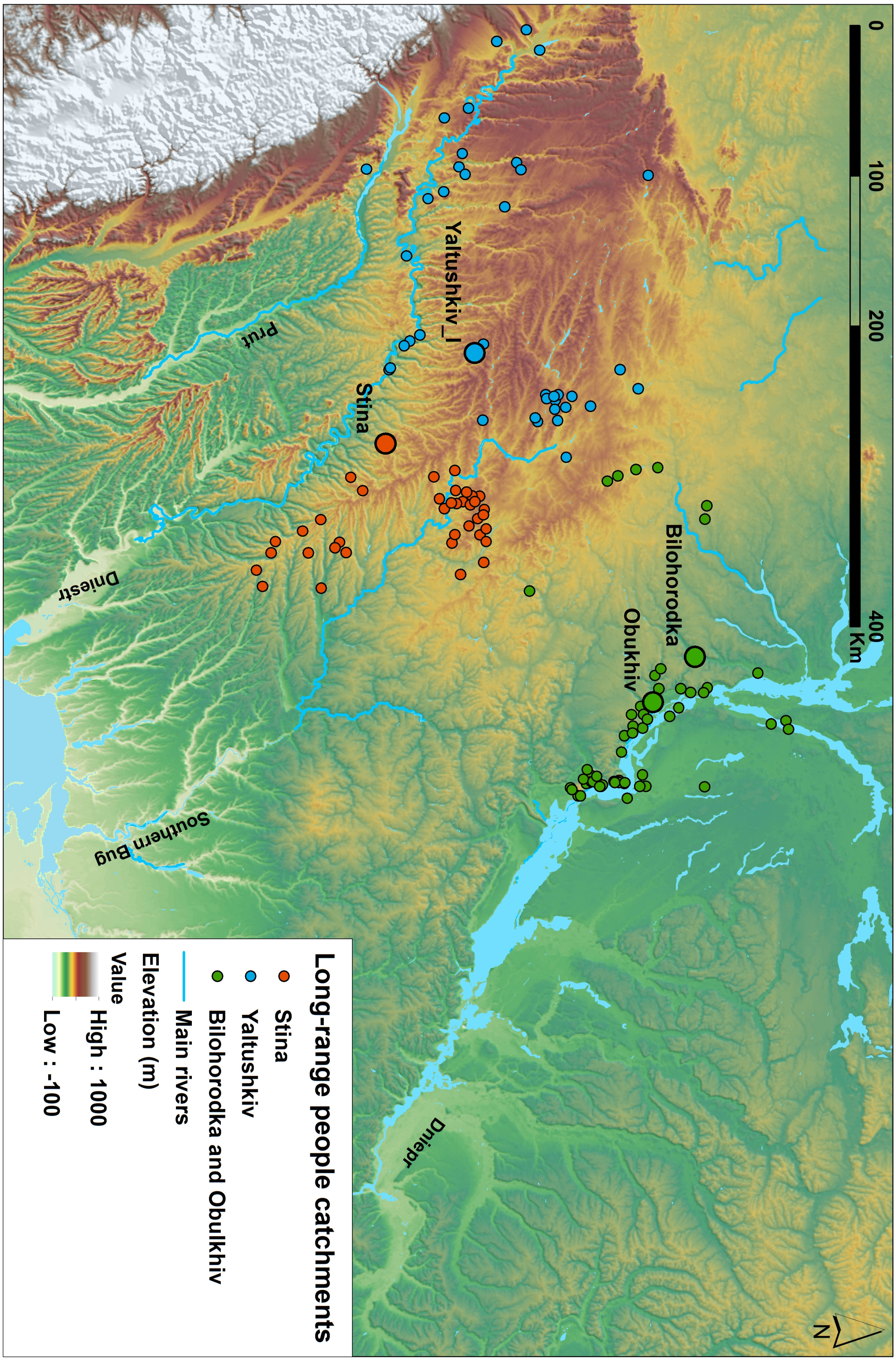

Fig. 5.27. Location of four CI megasites and their long-range social catchments.

If we plot the "neighbouring" sites' populations with the 'central' megasites, we observe a constant ratio between the two values for the four megasites (Fig. 5.28). The two megasites of Bilohorodka and Obulkhiv have been combined as it seems they are sharing the same neighbourhood along the right bank of the Dnieper river, which may have formed a 'natural' barrier with social meanings).
The ratio between the number of dwellings of megasites and neighbourhoods is significantly constant for the three cases (Stina = 2.16; Yaltushkiv I= 2.15; Bilohorodka/Obulkhiv = 1.70).

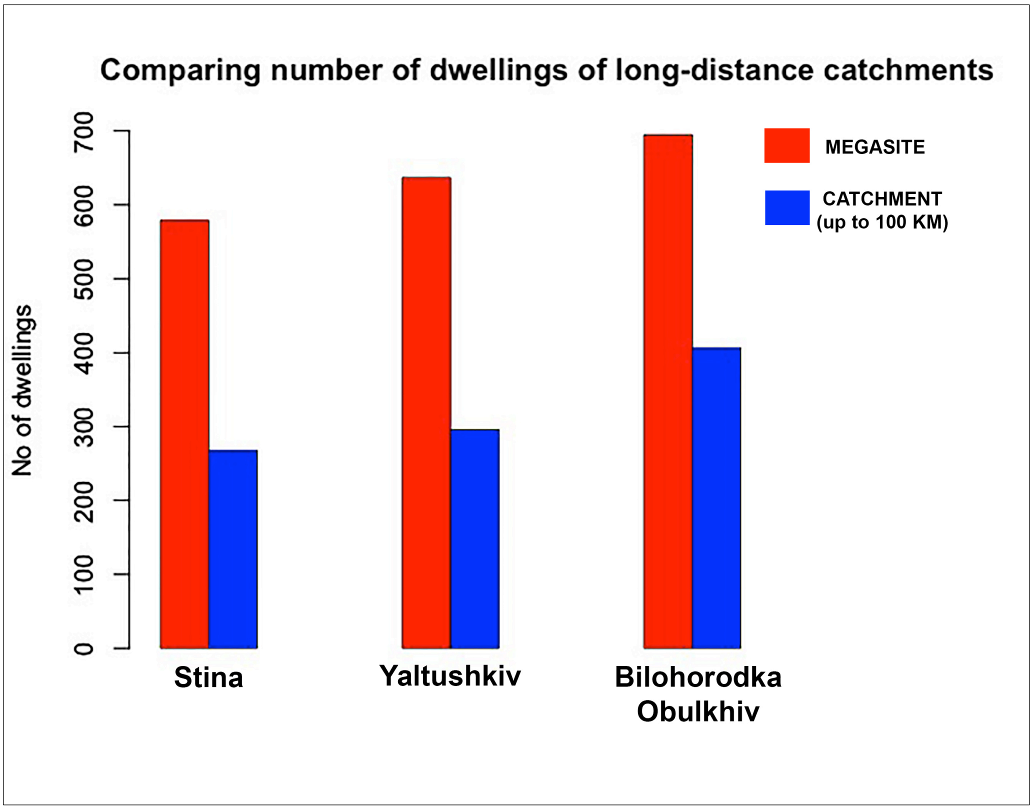

Fig. 5.28. Comparative number of dwellings of megasites (or pairs of megasites) and their respective long-range neighbourhoods.

This might suggest that, despite the inaccuracies in the data which preclude accurate population estimates, there is an overall pattern of megasites very capable of "hosting"/"accommodating" a large number of smaller sites at any one time (Stina = 37 sites; Yaltushkiv I = 38 sites; Bilohorodka/Obulkhiv = 59 sites). Moreover, from the bar chart (Fig. 5.28) we can include the possibility that the neighbourhoods could 'fit' even in almost half the area of a megasite. This could mean that the megasites could have been functional even when half-empty, or that the final layout that we detect with the geophysical survey is just the cumulative result of a sequential infilling process of an initial relatively dispersed dwelling distributional pattern.
Further geophysical survey of more megasites will help the understanding of these processes.

5.7.2 The population capacity of Nebelivka: a megasite within the *mega-cluster*

If we now take into consideration the only megasite with a complete geophysical plan to date, (Nebelivka – Trypillia BII), we can propose a model for the initial occupation of the megasite and assess its compatibility with the previous one discussed in section 5.7.1.

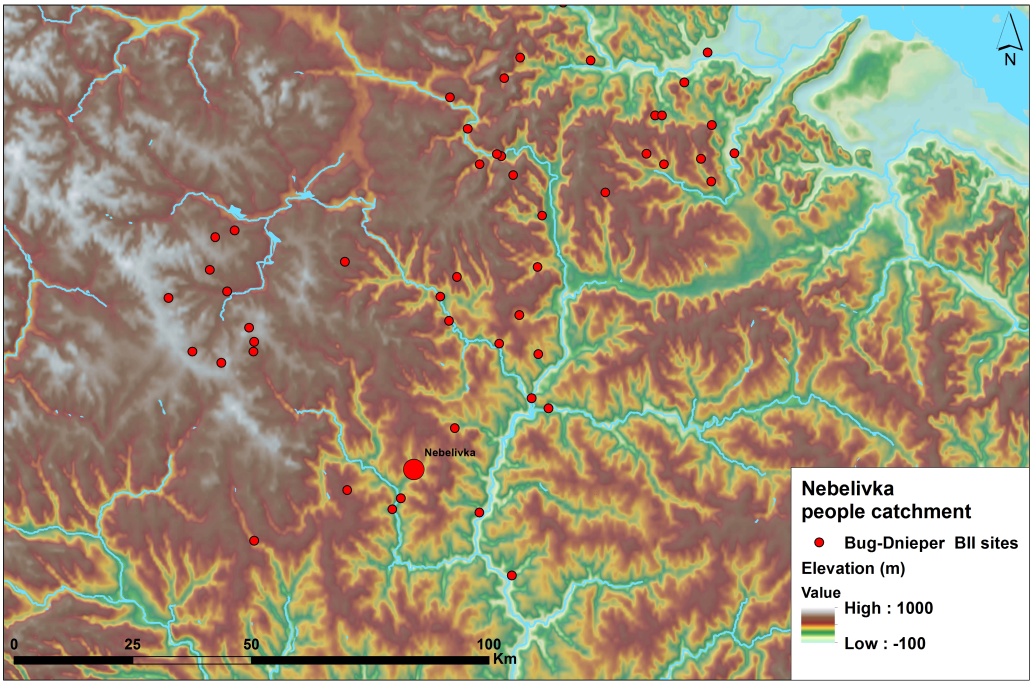

Fig. 5.29. 100-km 'neighbourhood' of Nebelivka.

If we consider a similar neighbourhood (approx. 100 km) of coeval settlements around Nebelivka, we count a number of 45 smaller sites (Fig. 5.29). Excluding other BII megasites, the number of dwellings of all the smaller sites can be estimated at 562 houses for the SBD interfluve phase BII. Starting from this estimate, it is possible to model an initial multi-focal occupation of the megasite of Nebelivka based on the distribution of 'Assembly houses' (Chapman et al. 2016), which can be considered as starting focal points for the initial occupation of the settlement in 'Quarters' (Fig. 5.30). As opposed to Müller et al. (2016, 266-268), there are other social explanations for the 'urban-like' planning and spatial organization of the megasite that will be broadly discussed in the next Chapter.

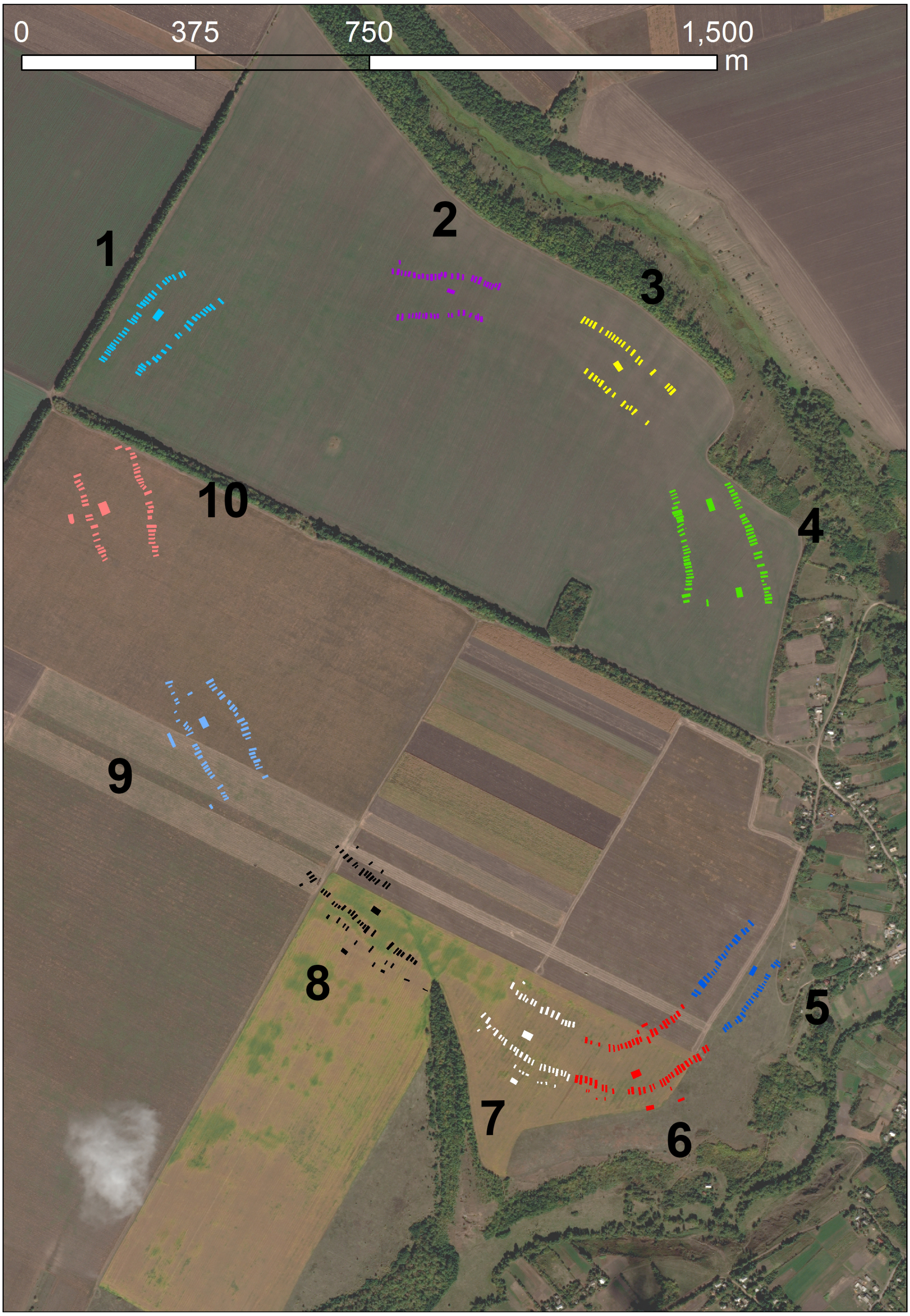

Fig. 5.30. Hypothetical initial occupation of Nebelivka, showing different quarters.

Further details on the development of the megasite plan will be discussed and can only be integrated in a social perspective in order to be fully understood.

Overall, despite the limitations derived from the data, we can still argue that the megasites were capable of “hosting” a large number of people coming from quite far away, at any one time. The estimates could definitely be changed and updated, as more data are produced in future research, but the inclusion of the whole database of known Trypillia sites opened the discussion to nuanced possibilities for explaining the appearance and development of these big settlements.

5.8 Conclusions

The aim of this Chapter was to explore a range of possible formal analyses of the Trypillia datasets, newly included in the discussion on megasites. The scope was to provide new evidence derived from the investigation of settlement data from different points of view, which can be summarized as follows:

1. There are no clear environmental-related reasons why the megasites are located in the ***mega-cluster*** within the Southern-Bug/Dnieper interfluve; hence motivations must be sought in the social human-interaction sphere.
2. With the development of megasites, there are two clear macro-settlement patterns that are established by the beginning of phase CI, clearly identifiable in the SBD ***mega-cluster*** of megasites and the rest of the Trypillia settlement distribution. With the increasing number of sites, including megasites, and the development of site nucleation throughout the phases BI, BII, CI, there is no evidence for the development of a single structured settlement hierarchy. On the contrary, the megasites stand out as exceptionally bigger than the rest of the Trypillia settlements, without a solid middle tier of sites.
3. There is a global and developing nucleation process of Trypillia settlements during the first four phases A, BI, BII, CI, whereas the last CII phase is characterized by a return to a more dispersed settlement pattern. On a local scale, the ‘centrality’ of megasites is measured by a statistically significant difference in site size at a scale of approximately 100 km. This figure seems to be consistent for around 1,000 years, without being affected by the increasing number of sites and their development and nucleation.
4. The immediate hinterlands of megasites seem archaeologically ‘empty’ and the human impact on the local environmental very marginal.
5. The megasites seems to be very “hospitable” and the evidence, so far, suggests that people from a large number of smaller sites from a long distance (~100 km) could ‘fit’ (i.e., visit) at any one time.

Overall, the new five lines of investigation bring fresh and original evidence to the study of the Trypillia megasite phenomenon that will be drawn together and integrated in an encompassing interpretative framework in the following Chapter.

Chapter 6: Trypillia urbanism?: a matter of temporal scale

6.1 Introduction

The previous Chapter presented the results of the Exploratory Data Analysis (EDA) approach, which identified, through a number of bespoke analytical tools, major patterns in the data that we shall draw together in an encompassing interpretative model. As discussed in Chapter 3, the methodological contribution of this research proposes a combined approach of quantitative analyses and interpretative narratives. McEwan and Millican (2012) recently edited a special issue of the ***Journal of Archaeological Method and Theory*** dedicated to the search for a middle ground where quantitative spatial analyses and experiential theory could meet to provide more complete archaeological and historical narratives (McEwan and Millican 2012; Gillings 2012; Llobera 2012). The attempt, so far, of finding a middle ground between GIS-based approaches and experiential archaeology has been focussed more on landscape perception, which is a common ground for the two sub-disciplines (Tilley 2004; Llobera 1996; Fyfe et al. 2010; Gillings 2009; Gillings 2015; Llobera 2011).
Conversely, the theoretical approach of this research tries to propose a narrative of the development of these large settlements, based on the results of spatial and statistical analyses, which suggest quantitative patterns in the data investigated. The amount of data that archaeology is yielding has been accurately described by Bevan as *"...largely digital, frequently spatial, increasingly open and often remotely sensed*." (Bevan 2015, 1473). This has prompted and encouraged the use and development of quantitative and statistical analyses, in order to investigate patterns and data behaviours, especially when dealing with this 'deluge' of archaeological evidence (Bevan 2015). As much as more formal and sophisticated analyses could help in understanding data patterns, archaeologists need to theorise the 'dry' results of quantitative analytical tools within qualitative narratives that explain the social behaviour at that human scale that sometimes seems to be left aside. The mining of big datasets such as survey data needs a critical theoretical interpretation and understanding, in order to help answer research questions related to the study of settlement systems and, more specifically in this research, to urban studies (Gaydarska 2016). The development of a data-led theoretical model for explaining the Trypillia megasites phenomenon represents an attempt to exploit the great potential of large datasets to answer "bigger" research questions (Wesson and Cottier 2014, 2) without getting lost in dry and meaningless numbers and statistics.

The following interpretative model is based on analytical evidence and explained by social constructs. The model will be presented as a biography of the megasites, trying to incorporate in the discussion their characteristics as they relate to formation processes, internal physical structure, social space, social organization, social activities, settlement growth and decline. Furthermore, the interpretation considered the full spectrum of possible explanations available given the limited resolution and accuracy of the data. A more dynamic model is more suitable when dealing with trans-scale analysis of coarse-grained data.

6.2 Formation processes

To start discussing the formation processes of Trypillia megasites, we have to consider their location in relation to the other settlements, the social catchment that these large sites can draw on and their internal structure. This draws together evidence at different scales in a holistic explanation.

6.2.1 The Mega-cluster

As discussed in Section 5.3, the majority of the megasites seem to concentrate within the South-Bug/Dnieper (or 'SBD') interfluve where a mega-cluster seems to be forming from around 4700/4600 cal BC with the development of the first large sites of Bagashivka II (100 ha), Kharkivka (100 ha), Vesely Kut (150 ha) and Vilkovets II (100 ha) (Fig. 6.1). Logistic regression analysis (see section 5.3.1) showed how locational strategies of megasites are not linked to specific environmental conditions of the SBD territory, but more likely there is a "social" explanation for why these large sites appeared and developed for over 1,000 years mostly in that area. Knowledge of that specific territory was acquired and transmitted since the initial Phase A of the Trypillia group (Fig. 6.2). The occupation of the SBD interfluve represents the Eastern "frontier" of the first Trypillian dwellers, whose settlement extended from the foothills of the Carpathian range into predominantly the major river basins (Dniester and Southern Bug). This shows a degree of knowledge of that "space", which probably had a significant value for people in the past who decided to make it into a series of "places", where to build massive settlements, thus showing a "special" bond to it (Bender 2002; Tilley 1994; Chapman 2000; Chapman 2012).

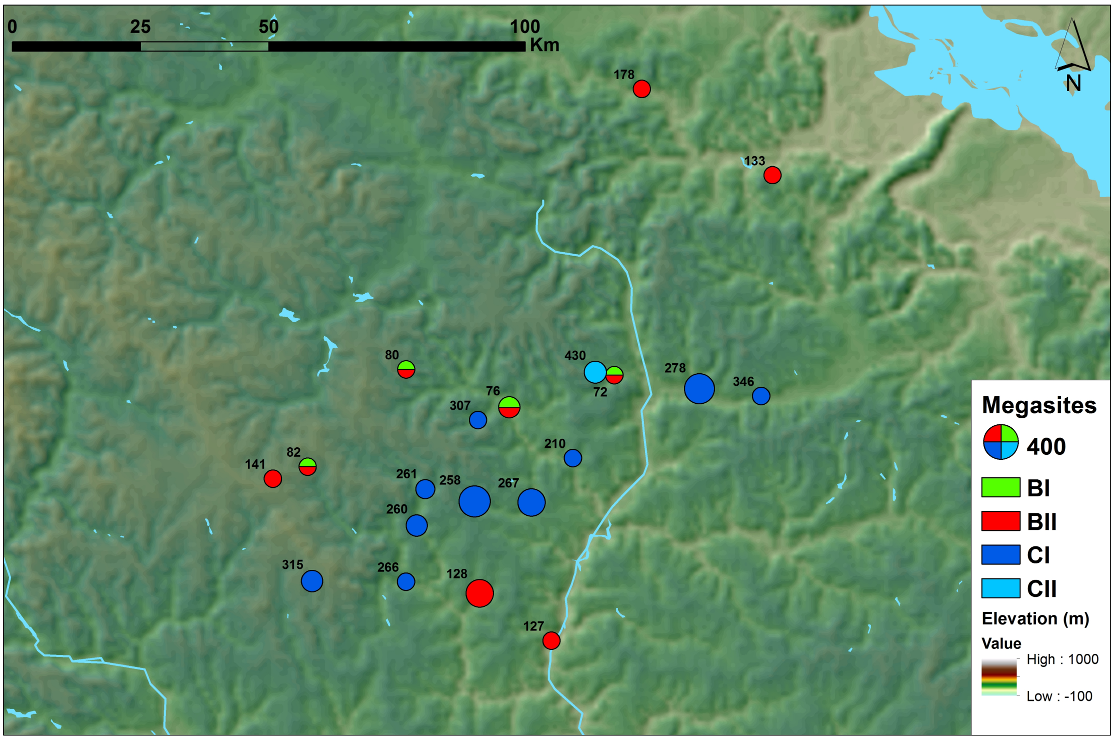

Fig. 6.1. Distribution of Trypillia megasites in the Southern Bug-Dnieper interfluve. (72) Vilkhovets II, (76) Veselyi Kut, (80) Kharkivka, (82) Bagashivka II, (127) Volodymyrivka I, (128) Nebelivka, (133) Myropillya, (141) Khrystynivka I, (178) Deshky, (210) Glybochok, (258) Talyanki, (260) Dobrovody, (261) Kosenivka, (266) Sushkivka, (267) Maydanets I, (278) Chychyrkozivka, (307) Romanivka, (315) Tomashivka, (346) Vasylkiv, (351) Yaltushkiv I, (421) Stina, (423) Bilohorodka, (430) Vilkhovets I.

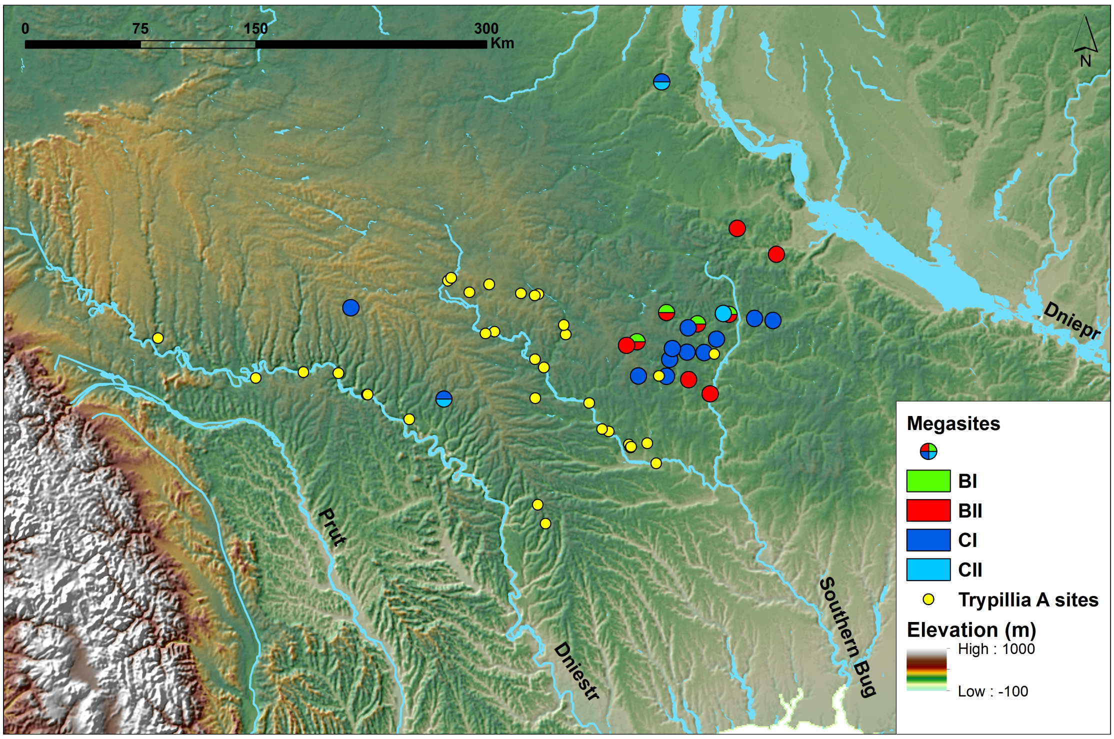

Fig. 6.2. Distribution map of megasites and Trypillia A sites.

We can argue that the appearance of the mega-cluster may be construed as the making of the “space” Southern-Bug/Dnieper interfluve a “special territory” that people ‘colonised’ during the middle of the 5th millennium (Chapman 1988). The continuous occupation of that territory for over 1,000 years, and the development of the largest sites in Europe at that time, made the SBD interfluve a territory that people identified and “marked” in order to identify themselves too (Strathern 1988; Chapman 2000, 185). The “landmarking” of the SBD area with megasites can be seen in the multi-modal settlement hierarchy developing within the interfluve (Fig. 5.11, 5.12, 5.13), which is remarkably dissimilar from the rest of the Trypillia territories. The development of site hierarchies (see section 5.4 also for references) has been interpreted in many ways; initially seen as strong evidence of social hierarchy, a variety of theoretical interpretations have subsequently developed (Duffy 2015). Nevertheless, a common trait of all these patterns is that ‘big/central sites’ are dispersed in the landscape and not clustered, as it appears to be in the Trypillia case. Only by looking at the wider picture of the whole dataset of Trypillia settlement can one notice that, in fact, the overall settlement pattern is remarkably different from the ‘classic’ multi-tiered hierarchy. It can, therefore, be argued that despite the SBD territory showing an apparent classic hierarchical pattern, it is more likely that the mega-cluster represents an unusual ‘special’ territory where a number of social and economic practices occurred. This can be construed as a way of defining a ‘special’ territory as well as ‘special’ social interactions, which might have been quite different from the ‘normal’ daily life in the rest of the Trypillia world. Moreover, the rest of the Trypillia area of influence presents what in rank-size jargon is termed a ‘primitive pattern’ settlement size distribution (Johnson 1980), which can be interpreted as indicative of a relatively egalitarian society with a larger ‘central’ settlement. Although this pattern has been interpreted as evidence for a low level hierarchical society (Milisauskas and Kruk 1984), we can argue otherwise if we question the permanent occupation of the ‘central’ sites, which, according to Milisaukas and Kruk are the focus of a regional decision-making organization (Milisauskas and Kruk 1984, 29).

The twofold settlement system, as here proposed, might be suggesting a dual societal organization within a single human group that we can only define by the material expression of their pottery production, limited metal production, building technique, settlement and dwelling customs[46]. The dualism identified at the global settlement systems scale will be discussed at the megasite scale below (see section 6.3.1.)

I shall discuss now the interaction between megasites and their regional hinterland trying to identify the catchment of people converging at these places.

[46] I will not discuss in detail the notion of archaeological culture; I leave it to the endless literature on the topic.

6.2.2 Social catchments

In order to build such massive settlements, a substantial number of people was needed, as for any monumental site or landscape (Dietrich et al. 2012; Artursson et al. 2016).

It is difficult to estimate the number of people needed to build a Trypillia megasite, as there are a number of variables that hinders even a sensible guesstimate, such as the efficiency of stone tools, skill levels, etc. (Johnston 2015). Nevertheless, Artursson et al. (2016) proposed 160,000 person-hours of labour to build the Neolithic megalithic complex of Döserygg (Southern Sweden), that spread over 60 days implied a total of c. 333 persons. Based then on the population density of the surrounding areas and a supporting population of 1,665 people, Artursson estimated a social catchment radius of 16-23 km from the megalithic site (Artursson et al. 2016, Table 1). Similar calculations have been made, as a comparison, for the earthwork of Poverty Point in Louisiana (Gibson 2001), a monumental construction in a low-density society. The catchment radius for the construction of the mound A has been estimated to be of 70 km (Artursson et al. 2016, Table 1). The relationship between these permanent monumental sites and the low-density societies that built them and lived near them can be compared to the relation that Trypillia megasites had with the contemporary agrarian society that built and used them. The comparison can be based on the fact that Copper Age megasites as well as Early Neolithic monuments clearly represented ‘special’ places within ‘special’ landscapes; megaliths were ‘special’ for their symbolic significance, megasites for their sheer size as the largest in Europe at that time. As megaliths represented place of ‘collective identity’ (Renfrew 1976; Whittle 2003), so did the megasites for Trypillia society. The start of the ‘collective identity’ is the collective construction of megasites, through what Dietler and Herbich defined as ‘collective work events’ (Dietler and Herbich 2001). Although Artursson discusses the construction of complex monuments, it can be argued that similar processes of non-coercive social organization and coordination might have been triggered by the sheer “construction phase” of Trypillia megasites, with the mobilization of a large part of the population. Conversely to Early Neolithic complex monuments in Sweden, whose construction triggered the development of social hierarchies (Artursson et al. 2016, 12), based on a regional level, Trypillians developed a more ***bottom-up***-derived regional coordination, thus stressing the collective value of megasites as opposed to the symbolic and political power value of Early Neolithic monumental sites.

In terms of the social catchment of people mobilized to build Trypillia megasites, we can consider the figure of ~100 km radius, at which the megasites’ sizes ‘stand out’ as high value outliers within a cluster of low values (see section 5.5.2.4). The statistical significance of megasite sizes compared to the cluster of smaller sites is solidly consistent throughout almost 1,000 years of megasite use (Fig. 5.18-19-20). Therefore, we can argue that the figure of ~100 km has a significant and long-lasting meaning in the relationship between megasites and smaller settlements (Fig. 5.27-29). The relative capacity of the megasites has been demonstrated to be sufficient to 'fit' people coming from up to 100 km, even without necessarily occupying whole megasites at once (Fig. 5.28). The figure in fact, shows that people coming from within that distance could 'fit' in half of each megasite. The mobilization of large numbers of individuals must have required some sort of formal coordination and organization, especially to gather people coming from far away. Even assuming a predominantly egalitarian community, we can argue that Trypillians must have developed supra-village social organization in order to coordinate the considerable workforce needed to build such large settlements. Artursson (2016, 15) argues that, in order to mobilize such a wide catchment of Early Neolithic people, it would have been unthinkable to do so by coercion. This would have meant, especially for low-density societies such as Trypillia, the dispersal of different groups coming from remote distances, perhaps even 100 km. We can think that people would have come together for a number of reasons and in a number of ways. The movement of people might have been driven by what Dietler defined as "commensal politics", where a part of the population gathers for public ritual activities (feasts); which are centred around the communal consumption of food and drink (Dietler 2001, 67; Hayden 2014). The communal consumption of goods is seen as a way of congregating people to build a site or a monument and rewarded as an incentive for their contribution (Dietler 2001). The ritual dimension of these social gatherings prompts the development of political hierarchies within the management of workforce recruitment, site planning, activity coordination, and site maintenance (Dietler 2001; Hayden 2014). Although there is no material evidence of the development of hierarchies within the Trypillia group, it can be argued that 'someone had to take decisions in order to build the site and to perform collective activities'. In this sense, more likely, not a hierarchy, but a supra-village social organization developed for the building of Trypillia megasites. The level of mobility proposed by Kent (1989) for farming societies could be seen as applicable to a Trypillia population that was used for periodic visits to the ***mega-cluster*** territory, where the 'collective identity' was strengthened by communal rituals and possible occasional exchange of material goods with the steppe communities. The vast extent of megasites would have allowed a considerable amount of people to dwell at any one time. To illustrate this point, I shall discuss now the possible internal structure and development of one of the BII megasites - Nebelivka in the Kirovograd Oblast.

6.2.3 Internal structure of the megasites: the case of Nebelivka.

Other evidence that suggests that Trypillia must have developed a minimum level of social organization and hierarchy is the formal planning of the settlements (Fig. 6.4). The advantage of modern geophysical survey is that it allows the identification of a much larger array of different archaeological features than previously detected (Chapman, et al. 2014). In Fig. 6.4, we can appreciate the level of detail that could be reached at the site of Nebelivka, which, combined with excavation data, helped in the understanding of the settlement interpretation. One of the main objectives of the overall TMP was to obtain an internal chronology of the megasite, by means of AMS dating of samples taken from different structural features of the site. The sampling strategy aimed at an even coverage of the full extent of the settlement, by test-pitting individual geomagnetic anomalies interpreted as the remains of Trypillia dwellings (Fig. 6.3). The Bayesian modelling of over 80 radiocarbon dates is on-going, but the preliminary results show a period of occupation of 150 years, from 3950-3800 cal. BC.[47] Therefore, we can only speculate, meanwhile, on possible formations and developments of the settlement from a social and morphological perspective.

[47] Millard et al., Forthcoming. ***Dating Nebelivka: Too many houses, too little time***. To appear in the project monograph.

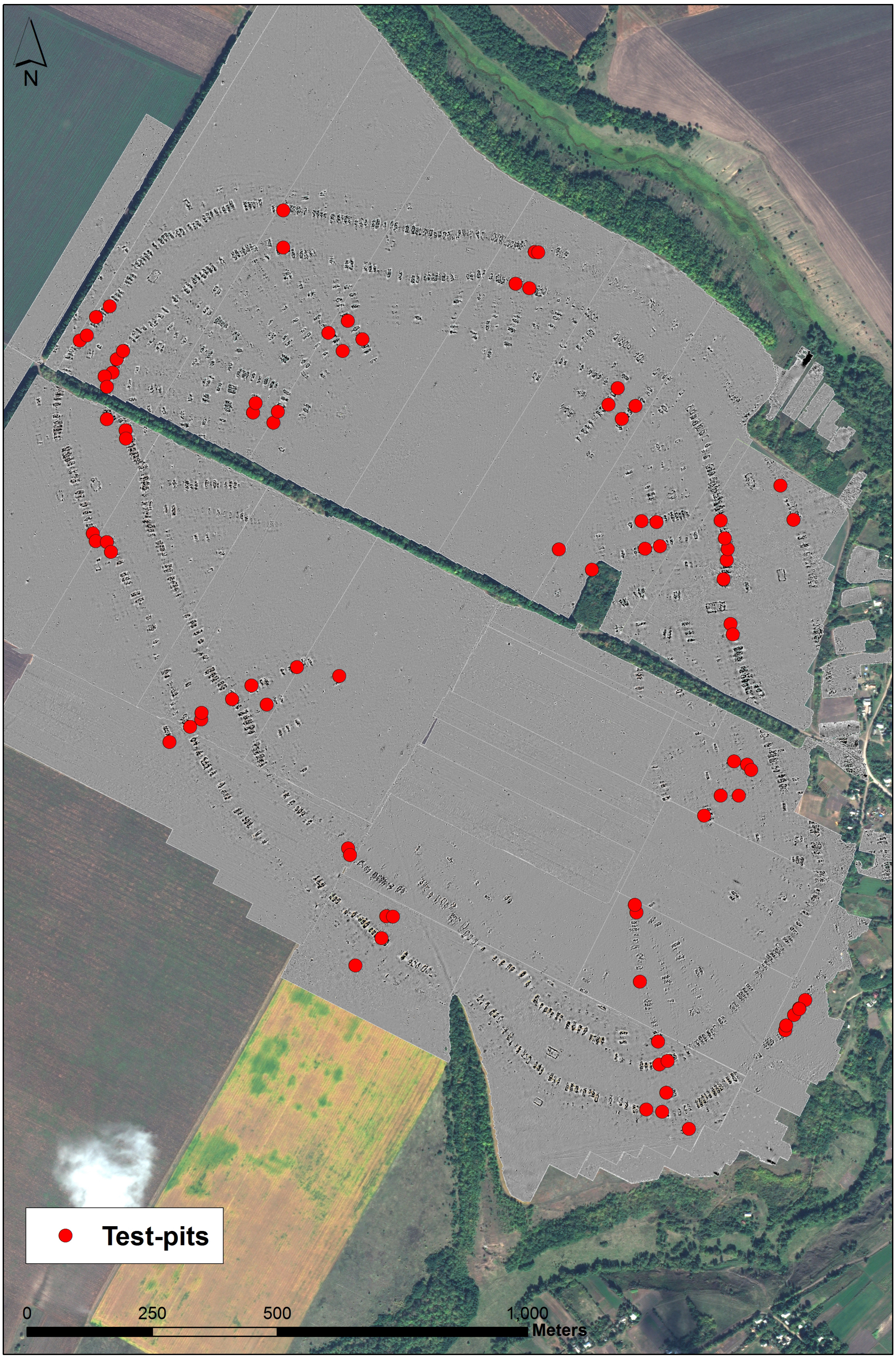

Fig. 6.3. Locations of test-pits over Nebelivka geophysical plan.

6.2.3.1 A social perspective of physical settlement formation

The great advantage of having the complete plan of a megasite with modern geophysical techniques means that a number of intra-site features can be discerned

– not only the overall structure but also a wealth of details (Chapman et al. 2014). Therefore, for the first time we can appreciate the layout and internal structure of these massive settlements and discuss arguments about the level of complexity of social organization with a set of new evidence. At first glance, the site of Nebelivka seems to have quite a significant degree of spatial organization, with a number of patterns showing at the site scale (Chapman et al. 2016). The 'built-up' area made of 'regular' and 'mega houses'[48] (plus the so-called 'mega-structure' (Chapman et al. 2014)) arranged in two concentric circuits and radial rows leading towards an 'empty' centre, all surrounded by an enclosing ditch, are the main archaeological features that can be detected on the complete geophysical plot (Fig. 6.4). More subtle features are a number of 'soil-filled' geophysical anomalies, interpreted as traces of pits, that sometimes manifest themselves as uniform dark patches along the front (or the back) of dwelling alignments. Considering the main architectural elements of the megasite ('regular' houses, 'mega'-houses, the ditch, the empty space) and how they are laid out, it is possible to propose a theoretical model of the settlement formation, based on morphological constraints and social relations.

Given the complex layout of the megasite, there must have been an initial spatial organization that would have hinted at the complete plan. Despite the number of possibilities, I shall try to combine this starting assumption with the social development of neighbourhoods and quarters in an urban as well as non-urban environment. The social dynamics that can be possibly argued for the development of a Trypillia megasite like Nebelivka will be discussed on the basis of the material evidence of the archaeological remains mapped from the geophysical data. The concepts of 'neighbourhood' and 'quarters' (or districts) have mostly been associated with the concept of urban settlement (Glass 1948; Suttles 1972; Smith 2010).

[48] Chapman et al (2016) term these bigger structures as "Assembly Houses" thus attributing them a specific social use as structure where people used to aggregate and socialize. This prevent them from being mainly residential houses of the 'quarter's representative', or simply a warehouse were to store shared resources within the 'quarter'. Unfortunately only the 0.3% of all these bigger structures has been excavated so the use of those is still very speculative.

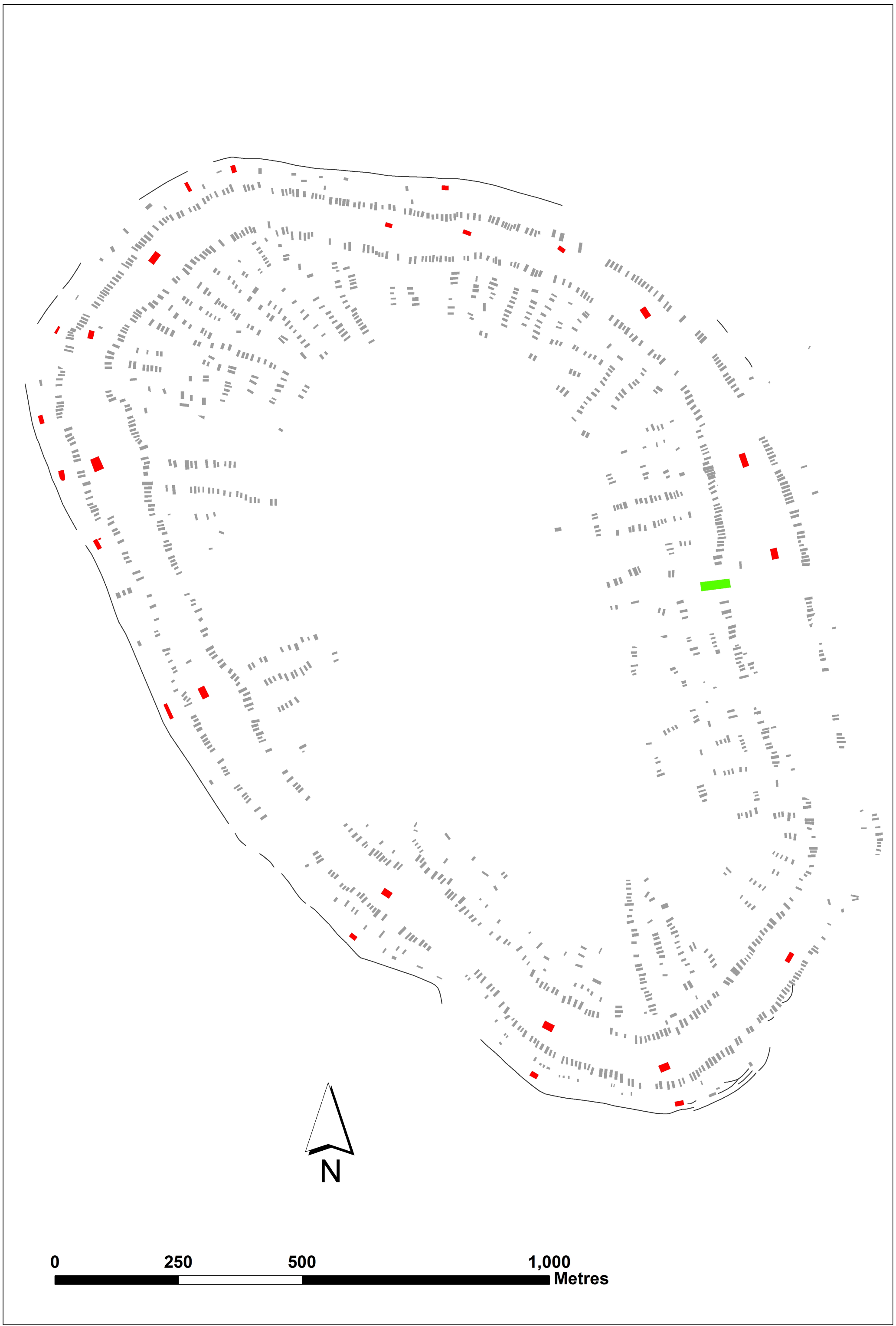

Fig. 6.4. Digitised plan of the Nebelivka geophysical survey. The main architectural features are displayed: 'regular houses' (grey), 'mega houses' (red), 'mega-structure' (green), and external ditch (black).

More recently, scholars have started discussing the growth of neighbourhoods in semi-urban settlements in archaeological terms (M.E. Smith et al. 2015). In this sense, we can argue that the development of neighbourhoods is not strictly connected to the development of an urban site or not, but rather was probably more related to the large dimensions of the overall settlement. Therefore, we can discuss the social meaning of neighbourhoods and then define possible trajectories of how these units might have influenced the development of Trypillia megasites.

The earliest definition of neighbourhood is that of a distinct territorial group with specific physical and social characteristics (Glass 1948, 18); and the second earliest is that of a network of acquaintances with shared conditions of residence and common usage of local facilities (Suttles 1972, 55). In both definitions, there is a clear connotation of social identity, both in terms of common values and shared space and resources. If we combine these elements with the discussed wide social catchment of Trypillia megasites, we can argue that the common values could be seen in the common provenance from a remote small village or group of villages. People coming from up to 100 km have surely had fewer inter-personal contacts, of any sort, when living in their villages than when they came together into a megasite. Even small differences in local customs and village life ways could have been the main social drivers for the formation of different neighbourhoods within the megasite. Pre-existing social ties, formed in the villages of origin, are usually reported in urban contexts, and facilitate the development and clustering of people into neighbourhoods (Lewis 1952; Anthony 1997). The 'village identity' is, therefore, reproduced in the 'neighbourhood identity', within the megasite. Differences between villages are causes for disputes and behavioural incompatibilities; hence a minimum degree of spacing is needed in order to maintain a social equilibrium within the large settlement. The spacing can been identified with the construction of bigger buildings ('mega houses') which results in their regular distribution along the perimeter of the megasite. The 'mega houses' could have represented nodal references for the clustering of neighbourhoods (alignments of 'regular houses') into larger spatial groups of dwellings that we can define as 'quarters' (Fig. 6.5).

The reconstruction displayed in Fig. 6.5 represents a possible initial occupation of the megasite of Nebelivka. The hypothetical first plan of the settlement set out the imprint of the overall final layout of the site, that we can see today, thus satisfying the morphological assumption discussed above.

Alongside with the major architectural features, another peculiar element (often neglected among Trypillia scholars) of the settlement planning sees its first manifestation since the initial phase of the megasite occupation: the central 'empty' space.

The planning and construction of 'regular' and 'mega' houses left an apparently *unbuilt* central area which is, in fact, well defined and the nodal feature of the entire settlement (Fig. 6.4).

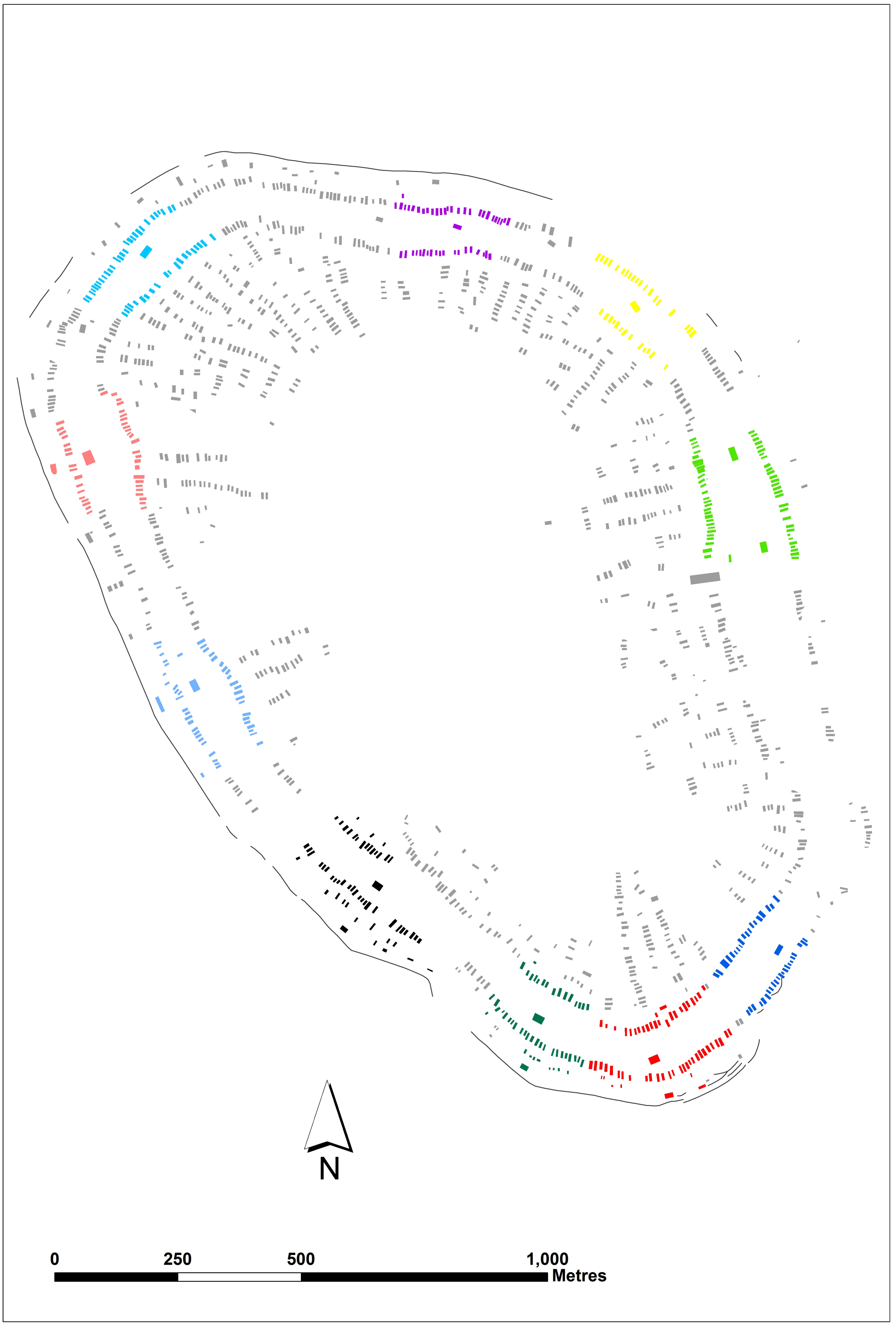

Fig. 6.5. Hypothetical reconstruction of the first organization of Nebelivka, showing quarters.

M. L. Smith discusses the importance of ***empty spaces*** in urban environments as deliberately 'built' as part of the architecture of the city (M.L. Smith 2008, 217). But it can be argued that urban contexts are not the only form of settlements where ***empty spaces*** have an important role in the social and daily life of a site. There are examples of non-urban settlements that show empty central areas, such as the 0.5 ha Neolithic site of Hallan Çemi in Turkey, traditionally interpreted as a feasting place (Rosenberg and Redding 2000). On the opposite side, a modern massive non-urban site (*c.* 630 ha) like the Black Rock Desert location for the Burning Man festival, reserves the central ***empty space*** for social and artistic manifestation (M.E. Smith et al. 2015). Wust and Barreto (1999) discussed the importance of 'ring villages' with an 'empty' middle for the consolidation of previously distinct cultural groups within a context of inter-groups negotiation and relationships in the 9th century AD Amazonia. Grave and Keuren (2011) talked about plaza-oriented Pueblo villages in the 14th century AD, and their principal function as 'panoptic settlements' where public ceremonies (executed in the empty middle – plaza) were performed to mitigate social instability. The common connotation of these blank places is the lack of material remains and the high social value and meaning that they embody for the inhabitants of the settlement. As such, we can argue that these were deliberately 'built' within the overall planning of the settlement, whether this is or was conceived as urban or not. These 'places' were the fundamental 'architectural' features of megasites thus making them a distinctive form of settlement compared to villages. The deep collective meaning of ***empty spaces*** goes beyond the mere activity area they represent, as they also have a practical utility of 'social safety valves' within settlements where an increased density of occupation might generate tensions and discords (M.L. Smith 2008, 218). On the other side of the coin, their preservation and management required a minimum of social organization and accord in order for their long-term communal use. Potential social activities performed in ***empty spaces*** will be discussed in the next section (6.2.4).

6.2.4 Forming social places and identities: a bottom-up/ top-down process

Overall, the megasite formation process shows a number of different, but interrelated, trajectories towards the development of new identities along with the reinforcement of old ones. The different processes carry both ***bottom up*** and ***top down*** connotations that can be seen at different spatial scales. A number of diverse drivers can draw a large population into a specific place (M. L. Smith 2003, 2); this itself assumes a level of social organization (***top-down***) within the inter-regional domain and the acknowledgment of this organization by the population (***bottom-up***). The place (mega-cluster) symbolizes the inter-regional identity as it represents an ***unusual/special*** space to the ***normal*** living environment of provenance (small villages). Therefore, the 'mega-cluster identity' is established and distinguished in contrast to the 'village identity'.

The ‘mega-cluster identity’ is materialized by the megasites, where people come together to interact in a number of ways at a specific, ***special*** location. The construction of the megasites is the first interaction and initial driver for the development of the new identity by the population (***bottom-up***); but it is coordinated by an inter-regional decision-making (***top-down***). The increasing level of village clustering, outside the ***mega-cluster*** (Fig. 5.13), can be construed as a gradual development of a ‘village groups’ identity that represents a closer interaction between neighbouring villages. This can be seen in the megasite at the level of ‘quarters’ that may have represented village groups within the megasite. A further level of social coordination can be argued for the megasites where, perhaps a village group, on a yearly rotating basis, might have coordinated the collective activities on site (***top-down***). The village group ‘in charge’ of the organization and coordination of collective activities, was allocated in the ‘mega-structure’ whose excavation did not produce more material variation than a ‘normal house’ (apart from a number of miniature vessels and a small piece of gold). The ‘quarter’ built around the ‘mega-structure’ could have been occupied by members of the villages part of the group ‘in charge’ of the activities for that year. The size and spatial location on one of the main entrances of the ‘mega-structure’ within the settlement are harbingers of the ‘importance’, even if only temporary, of the village group inhabiting it, compared to the rest of the megasite dwellings. Location, and not just monumentality, can be expressions of social differentiation (Wust and Barreto 1999, 15). The ***top-down*** organizational level expresses itself through the physical planning of the megasite, thus allocating a specific location where to build the site (enclosed ditch) and assigning different spots for the establishment of neighbourhoods clustered in quarters. The development of neighbourhoods and quarters is probably left to the different village groups (***bottom-up***), who self-organized and shared resources (***bottom-up***); arguably people coming from the same areas shared resources and building material for the construction of the dwellings (this argument can be sustained by the size variability of houses in different quarters (Chapman et al. 2016)). The self-organised house building facilitated the self-organization of the entire site as people naturally interacted with acquaintances[49] (Lewis 1952; Anthony 1997). In this way, the ‘village identity’ is reproduced into the megasite, and possibly reinforced by the interaction with different groups. Each village or group of villages, as they do “at home”, share facilities and resources within neighbourhoods and quarters. Moreover, an initial minimum spacing between groups serves as a deterrent for friction and disputes among different villages (Fig. 6.5). As for the communal side of the megasite architecture, the big ‘empty middle’ is collectively ‘built’ within the design of the whole settlement. The administration and management of it can foster both social cohesion and discord, especially in the absence of a

[49] Although here I am discussing seasonal movements rather than migrations, Anthony (1997) stresses the vital role of family or kinship ties during migrations.

robust social hierarchy not strong enough to enforce decisions. There is no material evidence of the development of a social hierarchy within the megasite, as similar pottery production has been found in all the different types of archaeological features excavated, hardly any evidence for special or exotic finds has been recovered, and the material recovered in the 'mega-structure' is not significantly different, also in terms of relative quantities, from a 'normal' house (Chapman et al. 2014).

The 'empty middle', instead, is the "materialization" of the 'megasite or mega-cluster identity' where people with different 'village identity' interact.

Most likely the differences between 'village identities' and 'megasite identities' were stronger in the initial phase of the megasite's formation. Both their negotiation and clarification were most likely the main drivers for how the site developed.

6.3 Social organization and settlement development

The identity dualism is at the basis of the social organization that the megasites, most likely, developed and supported their growth and duration for almost a millennium. The sheer scale of human groups living in the megasites would have required a certain degree of hierarchical organization (Johnson 1982; Chapman 2010b), although, not every human group of similar size organized itself in similar ways (Feinman 2011, 43). This statement is sustainable for Trypillia megasites if we assume they are ***permanently*** and ***entirely*** occupied at any one time, which is an assumption that nobody has really challenged yet (Chapman and Gaydarska 2016, 292). Given the evidence provided by recent investigation and data analysis examined in Chapter 5, I will now discuss an alternative view on the social organization and settlement development starting from the proposed combination of *top-down/bottom-up* formation process.

6.3.1 Hierarchy vs. egalitarism: is there a middle ground?

The dichotomy between hierarchical and egalitarian societies has been long discussed with supporters of Rousseau's vision of an innate powerless nature of the human kind against Hobbes's view of a natural tendency towards unequal organizations of human groups (Wengrow and Graeber 2015, 599). Boehm (1993; 1999) argues that the complexity of human political repertoires is what differentiates us from the great apes' social interactions and that the endless debated dichotomy is not sustainable for humankind (Boehm 1999, 3). There are a number of examples where an ambivalent social structure has been argued for agrarian and urban societies, thus overcoming the binary alternative between 'egalitarian' versus 'hierarchical' (aka 'simple' versus 'complex') and proposing an alternated coexistence of the two (McGuire 1983; Ehrenreich et al. 1995; McGuire and Saitta 1996; McIntosh 1999). Wengrow and Graeber (2015) propose the application of these models to hunter-gatherers' communities, relating them to a seasonal variability of social structure. Similarly, I argue that this model is applicable to the Chalcolithic Trypillia group and that the seasonal-based dual societal organization can find its materialization in the development of megasites in the Southern Bug-Dnieper interfluve.

Already proposed for megasites' formation processes, the interplay of ***top-down*** and ***bottom-up*** components can be argued also as a form of social organization of a generally egalitarian group that developed a temporary supra-village social structure during seasonal gatherings at the megasites. The evidence for the development of a coordinated social structure has been previously discussed as mainly prompted by the construction of monumental meeting sites (Dietrich et al. 2012; Artursson et al. 2016). There are numerous drivers for social gatherings that foster the necessity of 'organizing' a temporally more structured community of people; and probably also numerous collective activities conducted in the 'empty' communal space. Feasting, marital exchanges, trading, resolving of inter-village (or inter-village groups) disputes, religious rituals are all potential collective activities that needed a degree of supra-individual and supra-household coordination. The interactions between different 'village identities' clashed with a moderately enforced 'megasite identity' but the necessity of gathering for a number of socio-economic reasons required the development of an inter-regional social coordination. The lack of monumental architecture and of 'special goods' along with an undeveloped mortuary domain in which to display different social status is the main evidence that the idea of a strong, permanent and structured socio-political organization is highly unlikely for the Trypillia population. More likely, an inter-regional decision-making political body developed during collective gathering events, where a generally egalitarian society is coordinated, seasonally and locally (only at megasites), on a yearly rotating basis, as discussed above. The dynamic and dual organizational structure of Trypillia can be argued at the megasite level where the 'village identities' are overshadowed, but not overcome, by the temporary supra-village social organization. The wide-ranging 'social catchment' of megasites (Fig. 5.27–29) was probably characterized by a substantial diversity of village groups, which (given the great geographical distances) rarely interrelated on more than a short-term (daily or weekly) basis. Hence, the close face-to-face interaction, occurring at megasites, exacerbates those diversities to the point that intra-megasite social groupings ensued almost naturally. 'Village group identities' are reproduced in the megasite and probably strengthened by the proximity of other groups. This facilitates the spatial and physical organization of a large settlement, where an enclosing dwelling area and allocated sub-zones are negotiated at the inter-regional level, but the house building and the resource – and facilities – sharing are left at the village level. As argued by M. L. Smith, ***food, goods and work*** remained, at least partly, within the individual decision-making domain even in developed complex societies (M.L. Smith 2012). In this sense, the household domain or, in the case of megasites even neighbourhoods, maintained a degree of autonomy, even within the agglomerated dwelling experience of the megasite. Moreover, the overall tendency of small villages to clustered dispersion in the rest of the Trypillia area of influence (Fig. 5.14), might suggest the development of a stronger 'village group identity', over the single village one, which tend to 'self-organize' into groups without showing a marked settlement hierarchy (Fig. 5.11-12-13) as opposed to the ***mega-cluster*** territory. A stronger 'village group identity' can be identified both in the overall settlement pattern, through the tendency of sites to cluster, and in the megasite planning, through the development of neighbourhoods and quarters. The initial spacing between 'mega-houses' - nodal points for the establishment of quarters - emphasised the differences among distinctive 'village group identities'. The physical division between quarters was still appreciable in the final layout of the settlement that we can observe on the geophysical map (Chapman et al. 2016: figure 1). The preservation of 'village group identities' within the megasite domain might have helped the overall organization and administration, where fewer quarters' representatives interacted more easily than larger groups of individuals. Similarly, Johnson (1983, 177) argues that larger domestic and household group sizes might have mitigated the intense scalar stress within the wider settlement. During phase CII[50], when megasites were abandoned, a noticeable North-shift, away from the ***mega-cluster*** area (MEGAXIT), marks the abandonment of the megasites' 'place' (Fig. 6.6-7). Remarkably, though, villages are still clustered (Fig. 6.7), thus showing how 'village group identity' overcame the collapse of the 'megasite (or mega-cluster) identity'. This can be construed as evidence for a general tendency of Trypillia population towards a more egalitarian village-based society, rather than a stronger political structure. A similar prevalence of 'less complex' social structures has been hypothesized for the transition to the Early Copper Age (c. 4500 BC) in the Great Hungarian Plain, where settlement clusters increased in number, but stopped being organized around 'supersites' or focal sites (Gyucha et al. 2013, 162). Consequently, it can be argued that, regardless of the social drivers that fostered the population agglomeration into megasites, even an egalitarian agrarian society like Trypillia developed a form of supra-village social decision-making that was needed to organize and coordinate the construction/destruction of houses and life in such massive settlements. Moreover, because of the overall tendency towards egalitarianism and village political autonomy, the constraint of ***top-down*** decision-making was sustainable only for a short amount of time and only in a specific place. Therefore, I propose a seasonal dual societal organization, where an egalitarian community developed a form of supra-village/inter-regional social

[50] The site record for phase CII has been integrated with data derived from Manzura (2005).

organization/coordination only during, and because of, collective gatherings in 'special' places such as megasites. The 'self-organizational' nature of this model makes the Trypillia case a plausible example of Chalcolithic ***heterarchy*** (Crumley 1995; DeMarrais 2016; Gaydarska 2016). Additionally, I argue that the seasonal component made it a more sustainable organizational structure than a permanent social structure, since tensions and frictions emerging from a ranked society eased down as soon as the 'collective life' was over (generally, there is very little evidence of warfare within the Trypillia group). I argue that the awareness of being a temporary situation, most likely, facilitated the interactions between people. Their 'special' condition of being coordinated to do something unusual and in close proximity with a large number of 'non-familiar' individuals could have, otherwise, provoked social tensions and frictions. The sustainability of a seasonal/temporary supra-village social coordination has been argued as long lasting model (approx. 500 years) for the Venezuelan El Gaván polity in the second half of the first millennium AD. Through short-term aggregations a process of negotiated cooperation between the leadership and the other members of the polity resulted in a sustainable mechanism of defence during wartime (Spencer 2013, 217). Spencer asserts that in this case the benefits of the intercommunity cooperation are higher than those at the intracommunity level, thus arguing for a sustainable temporary negotiated (between *top-down* and *bottom-up* social processes) cooperative social model even within a hierarchical society (Spencer 2013, 217). Thus, if this model could work in a hierarchical society like El Gaván, it might have been successful also for a mostly egalitarian society like Trypillia (more than 1000 years), on a seasonal and yearly rotating basis.

It is the seasonal component of megasites that needs further discussion, given the important social and political implications.

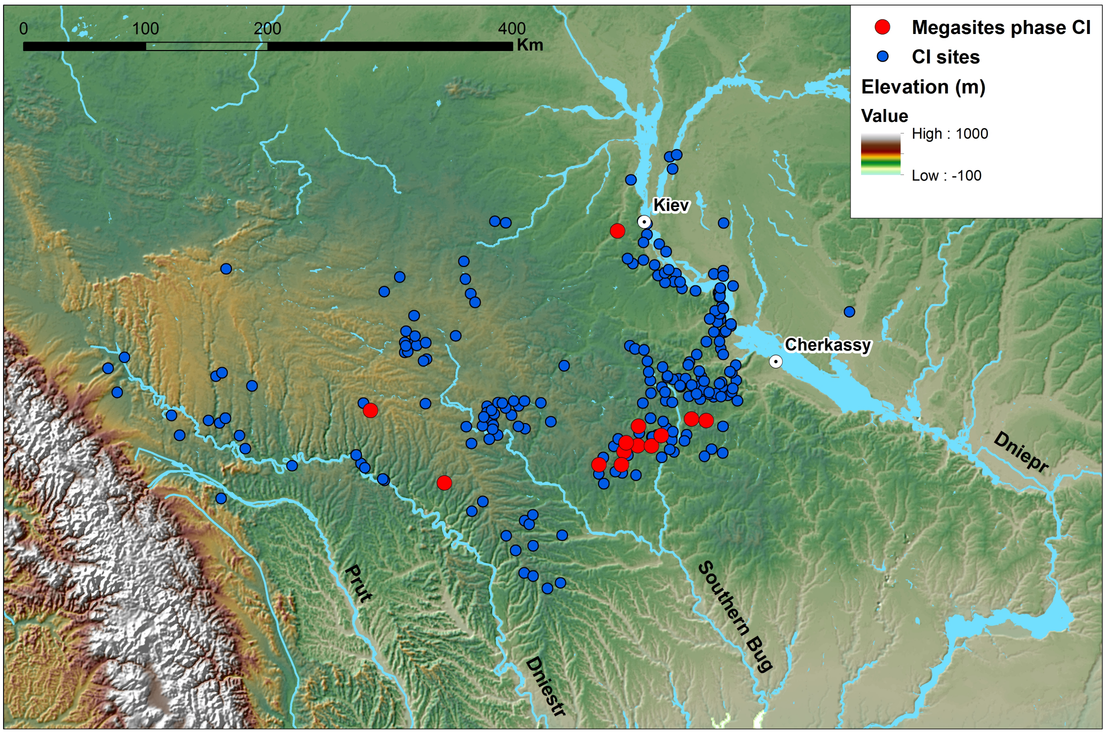

Fig. 6.6. Distribution of Trypillia CI sites.

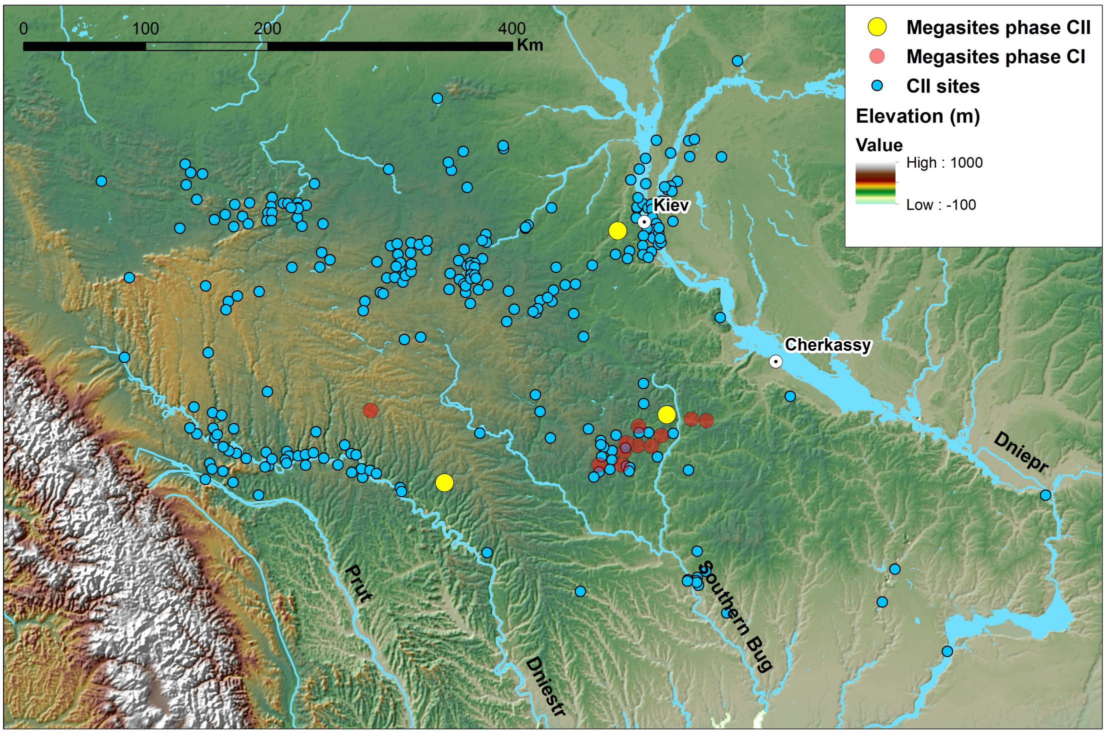

Fig. 6.7. Distribution of Trypillia CII sites. The map has been updated with data collected from Manzura (2005).

6.3.2 Seasonal 'Central Places'

The topic of seasonality has been broadly discussed in archaeology since quite early in the history of the discipline (Monks 1981). Mostly, seasonal sites or seasonal movements of people have been related to economic factors, such as fishing (Nandris 2007), hunting (Speth 1990; Nandris 2007; Frachetti and Maryashev 2007; Frankel et al. 2013), pastoral activities (Frachetti 2012; Aldred 2012), farming (Bogaard 2004, 50), and for general environmental instability (Parsons 1974; Tringham 1985; Bailey 1999; Lucero et al. 2015) to mention a recent spectrum of case studies. Commonly regarded as secondary, ephemeral and with little evidence of formal structure, seasonal sites have been identified with a certain degree of confidence as a set of unique evidence has been developed in order to define them as a specific class of sites (for Cucuteni salt exploitation sites, see Brigand and Weller 2013). Here I argue for the seasonal nature of Trypillia megasites, where a temporary supra-village social structure coordinated a range of communal activities for a limited period of time. There are a number of lines of evidence that would suggest the temporary occupation of the site, starting from the social implications of seasonal dwelling. As discussed in section 5.7, megasites were capable of fitting in a large number of the population, in fact all the coeval small villages could largely fit in all of the coeval megasites (Fig. 6.8).

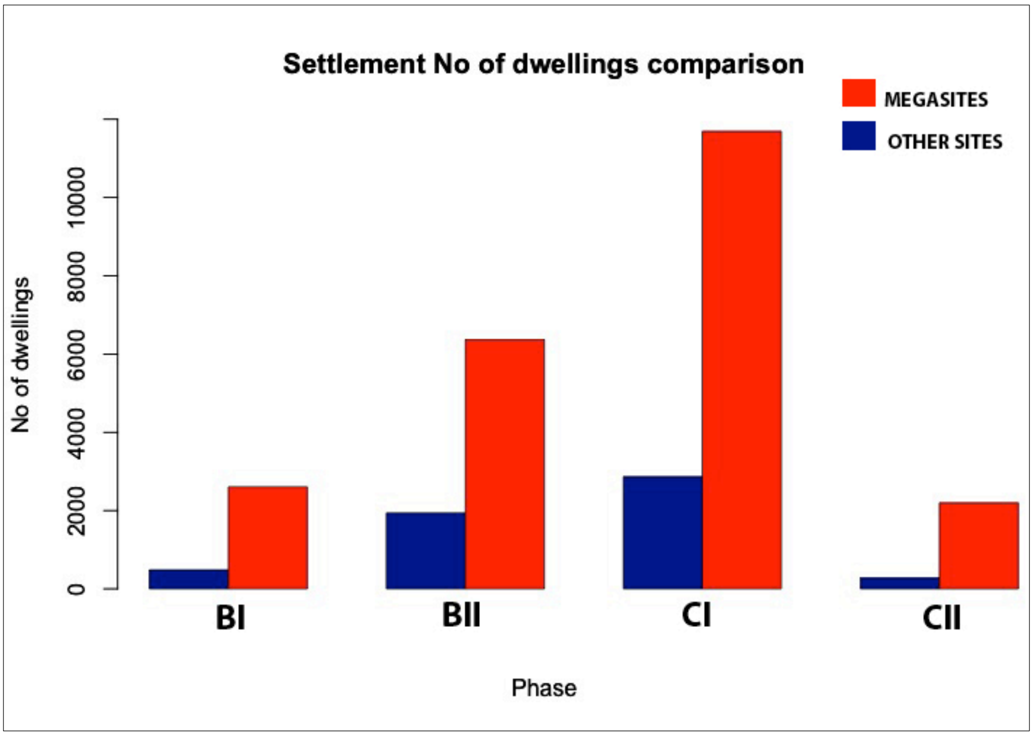

Fig. 6.8. Estimated number of dwellings of the sum of the small villages (blue) and the sum of the megasites (red) per phase.

This assumes the entirety of each megasite to be inhabited at the same time. But if we consider three factors, namely that 1) it could have been that only parts of megasites were occupied at any one time, that 2) there is a considerable rate of undiscovered small villages (and possibly a slim rate of undiscovered megasites) and 3) significant errors in the estimates, we can assume that the blue and red bars in Fig. 6.8 would be much closer in height.

The combination and variability of these three factors makes it difficult to estimate the population of a megasite (for issues regarding population estimates from survey and legacy data see Witcher 2011). Notwithstanding, if a seasonal factor is introduced, it is possible that, from a scalar stress viewpoint (Johnson 1982), a significantly higher number of people could have lived in the same megasite for a shorter period of time. The shorter time would have gone some way to limiting the scalar stress. Together with the lack of both monumental architecture and prestige goods (even in the mega-structure), it can be argued that a seasonal occupation of even large parts of the megasites would not have left substantial material evidence of a permanent hierarchical social structure needed in case of a permanent occupation of the megasites.

Another piece of evidence that may suggests a non-permanent occupation of these large sites is the little human impact that these have left in the immediate environment both in terms of botanical remains (Fig. 5.25) and in terms of evidence for intensive farming (necessary to support a large population (Shukurov et al. 2015; Ohlrau et al. 2016)) around, for instance, Nebelivka (Fig. 5.22). Pashkevich assumes a full occupation of megasites before arguing for a low-yield agriculture for Trypillians, with long periods of natural soil regeneration. This leads Paskevitch to propose a periodic settlement movement in order to take new 'virgin lands' into cultivation (Pashkevych 2005, 237; 2012). The problem with the movement of such a large population is that, in order to find a 'virgin land', people must have moved for tens of kilometres and build another megasite (compare inter-site distances in Ohlrau et al. 2016; figure 2-3-4). This would have needed a strong supra-regional political organization, evidence for which we are currently lacking. If, as in phase CI, the megasites were closer to each other, there was not enough 'virgin land' free to put into cultivation between, for instance, Talianky and Maidanesk (Ohlrau et al. 2016; figure 4). An alternative explanation would be that a seasonal occupation of even a high population would have left lower traces of human impact in the immediate environment than the archaeological evidence currently suggests.

Finally, physically and socially well-defined places such as the megasites would have made ideal landmarks characterized by a reliable solid architecture (Fig. 6.9), for annual return visits.

Fig. 6.9. Remains of a ‘normal’ burnt house, Taljanki.

The project’s house-building experiment demonstrated that a well-constructed house could over-winter in good conditions, with even the painting on the external walls being preserved), thus leaving the possibility of reoccupation in the next year, without major maintenance during the cold season (Johnston et al., n.d.). Contrary to the commonplace notion that solid architecture constitutes evidence for a permanent occupation, I argue that a settlement that is regularly occupied and lived for a limited amount of time in the year requires a reliable, solid architecture, especially if the seasonal movement of people is of long-range (approx. 100 km).

Overall, the model here proposed is that of Trypillia megasites as seasonal ‘Central Places’[51] based upon a wide-ranging social catchment, that was used to develop a temporary political hierarchy, with a two-stage development: first, build the settlement and then coordinate the collective activities most likely undertaken in the ‘empty middle space’. On the basis of the evidence so far collected, it is hard to tease out a precise range of communal activities. Therefore, we can only speculate, for now, that most likely a number of social events would have occurred at the megasites (Fig. 6.10).

[51] Not in the classic connotation developed by Chistaller (1966).

Fig. 6.10. Conspicuous deposition of animal bones in one of the pit-fill layers, Pit near House B17, Nebelivka.

The differences between the architectural features of megasites like Maidanetsk and Talianky (phase CI), pointed out by Chapman and Gaydarska (2016; table 1) might suggest a different function of these settlements. The high ratio of 1:2.3 of the 'empty middle space' over the total area of the settlement in Talianky, alongside the almost absence of 'mega-houses', might indicates a use of the megasite more related to social activity, rather than residency. Conversely, the megasite of Maidanetske with its smaller area of 'empty middle' space (1:7.7 ratio over the total area), and its higher number of 'mega-houses' (15 estimated), might suggests more a residential use of the settlement, which would need more organized planning (neighbourhoods and quarters), with little room for collective activities. Despite the uncertainty about the kind of social activities and organizations that might have occurred in Trypillia megasites, we can argue that these were significantly different ('special'), for the reasons here discussed, from the those conducted in smaller villages. Their 'special' value lasted for almost a millennium after which their 'centrality' collapsed, failed, was abandoned, ended, from the second half of the 4th millennium BC (Diachenko 2016). A similar social role has been argued for Late Iron Age 'polyfocal complexes' in Southern Britain (Moore 2012). Despite the remarkably different shape and form of these sites, the 'seasonal centrality' of the Iron Age complexes might find comparable meaning with Trypillia megasites; as social gathering places for a variety of collective activities; for their seasonal nature; for their importance in the 'making of a landscape' where diverse community identities interacted and maybe a supra-community identify developed; the lack of dense occupation.

The natural question that urges at this point is whether we can call the megasites' 'centrality' urban or not.

6.4 Early cities, large villages or neither?

The topic of urbanism as a phenomenon and the concept of the 'city' as a type of settlement have been in academic debate for more than 150 years now (Fustel de Coulanges 1864). Within the archaeological community, these topics have attracted the interest of many scholars as one of the fundamental tipping points of the human way of life. The research on it evolved quite rapidly both in terms of new data and new theories, especially in recent years. This is not the place to discuss the whole development of ideas, paradigms and debates that has been produced around urbanism and cities; for that, I refer to the main recent literature and relative bibliographical references (Childe 1950; P. Ucko et al. 1972; M. L. Smith 2003b; Cowgill 2004; Storey 2006; Marcus and Sabloff 2008; Gates 2011; Clark 2013). Many scholars have provided definitions of the concept of 'city' trying to identify the definitive idea; in response, other scholars have promoted different case studies and provided alternative definitions. The first proper check-list style definition was provided by Childe (1950) in his famous article on ***The Urban Revolution***, which identified 10 criteria that many criticized but often also included in their own explanations of the city. The impression is an overall tendency towards the creation of checklists, more or less strict and all-encompassing, and a general resistance to moving away from Childe's 'original sin'. However, in the last decade, archaeologists moved on from a rigid list approach towards more dynamic and broader ones, thus acknowledging the limitations of the Childean proposal. Cowgill (2004, 527-28) proposes a ***vague*** definition of city as a "***permanent settlement within the larger territory occupied by a society considered home by a significant number of residents whose activities, roles, practices, experiences, identities, and attitudes differ significantly from those of other members of the society who identify most closely with "rural" lands outside such settlements***" as well as measuring the level of 'cityness' of a settlement on the basis of a number of properties. M. E. Smith (2007, 4) provides a broad functional definition of urbanism: "***urban settlements are centres whose activities and institutions – whether economic, administrative, or religious – affect a larger hinterland.***" M. L. Smith (2003) focuses more on the social aspects of the urban formation and definition, by arguing that quantitative indicators (such as population size, density and area extent) must be integrated with qualitative ones and that the differences between urban and hinterland activities must be utilised (M.L. Smith 2003, 11). More recently, Flad (2016) explores the functional approach by proposing an analogy between urbanism and technology where he identifies four attributes that define cities from no-cities settlements: ***scale, differentiation, centrality,*** and ***performance***. Flad also stresses the importance of the processes through which the city as technology developed from existing technologies (e.g. dwelling practices, production etc…) (Flad 2016).

A very recent article teases out all the contradictions that archaeological urban studies have produced in the last 60 years (Gaydarska 2016). In her analysis, Gaydarska sees four major issues that arose over the last decades of urban studies that need to be addressed by the archaeological community in order to re-formulate the urban debate (Gaydarska 2016, 8-10). These can be summarized as follows: 1) the issue of applying the same definition at a local level and global (comparative) level, and how the presence or absence of the same criteria represent exclusion at a local scale and variability at a global one; 2) the problem with using a universal term to convey a non-universal content, also because the term evokes a modern conception of city; 3) the issue regarding the 'first cities' and the definition of the meaning of 'pioneering' a new form of settlement in a region of former non-urban lifeways; 4) a critique of the use of survey data and more specifically site size to define cities and settlement hierarchies. The 'solutions' proposed by the author are then: 1) adopt a system for 'measuring' the level of 'city-ness' based on a set of variables (or properties), like those proposed by Cowgill (2004, 527); 2), use local terms to refer to settlements that are not villages, and explain how they are perceived by the population that inhabited them; 3) define 'first cities'; both unsuccessful 'social experiments' that did not develop into a sustainable urban way of life and the ones that did, as they share similar characteristics despite the 'success' some had; and 4) develop a more robust theoretical framework as well as accuracy assessment procedures for the analysis of big datasets derived from a number of sources like field surveys, remote sensing and excavations.

After this very brief summary of the academic debate on cities and urbanism, how can we locate the Trypillia megasites in this debate?

Megasites have been defined in different ways depending on the set of criteria applied, whether as over-grown villages (Liverani 2013), an egalitarian, pre-state form of early, low-density urban settlements (Chapman and Gaydarska 2016), proto-urban forms of settlement (Müller et al. 2016), proto-cities (Videiko 2007), enormous villages (Bandy 2008), giant settlements (Kruts 2012) and pre-state cities (Wengrow 2015).

Müller et al.'s (2016) model is based on the spatial data and architectural organization of the megasites and the ***mega***-assumption (based on non-bayesian modeled calibrated dates) that all the structures were coeval, thus making scalar stress the main driver for the development of political hierarchy (Müller et al. 2016, 265). This, along with other social factors (Müller et al. 2016, 267) and their sheer size, prompts the definition of Trypillia megasites as proto-cities. There are limitations to this model as it does not include the other Trypillia coeval smaller settlements, thus considering megasites as 'normal' settlement forms, for that period (4100-3400

BC), rather than 'special places'. Moreover, the distribution of megasites is not explained in terms of why they are clustered within the SBD interfluve, as there are no particularly favourable environmental conditions to justify a massive migration that resulted in the permanent occupation of the SBD basin (see Section 5.3). The introduction of the temporary nature of the megasite's lifeway, embodied in the seasonal character, reduces the scalar stress, thus diminishing the immediate need for the development of a political hierarchy. Hence, the 'urban' connotation proposed by Müller et al. (2016) is not sustainable from a social point of view.

A reasonable example that could be compared to the nature of Trypillia megasites is the heterarchical, functionalist perspective of R.J. McIntosh and S.K. McIntosh on the Urban Complex of Jenne-jeno on the Middle Niger (R. J. McIntosh and McIntosh 2003). The definition of 'clustered cities' derives once again from Childe's checklist, despite the authors criticizing the Westernized nature of it. Craft specialization and economic interdependence, along with the unusual large size (compared to the 'normal' settlement form) of these Iron Age mounds, are the main characteristics for terming this settlement complex as 'urban'. The "clustered" distribution of these tells might suggest a comparison with the ***mega-cluster***. The functional interdependence between mounds can also be compared to a possible functional difference of Trypillia megasites (see above), although we do not have the in-depth archaeological knowledge to assert this as yet. The proposed heterarchical social organization can as well be a comparative aspect for the Trypillia group. All these comparable traits can lead us to a definition of "clustered cities" for Trypillia megasites, but fundamental differences preclude this possibility; the lack, for instance, of an immediate hinterland full of satellite sites that are functionally dependent from the mounds in the African example; or the seasonal component argued for Trypillia megasites.

Again, the use of the term 'urban' is here referring back the 'mega-ghost' of Childe's list, without a formal attempt to move on in the archaeological debate on urbanism.

A non-urban perspective to understand Trypillia megasites can be proposed if the attention is focused on the empty central space – one of the main features of the settlements' planning. As meeting places, megasites have parallels with Early Medieval assemblies, which were sites with structures organized and grouped around an open space that represented the main function and meaning (M.E. Smith 2007) of the settlement form (Semple and Sanmark 2013). Although there are potential commonalities between Trypillia megasites and Early Medieval assembly places, these are restricted to the role that such places played in terms of seasonal gathering of people from a broad '***hinterland***' to perform collective activities of different nature, including feasting (see Fig. 6.10 for evidence of feasting in Nebelivka) (Semple and Sanmark 2013). Notwithstanding, the ancestral value that the assembly places derived from pre-existing prehistoric monuments cannot be compared to the Trypillia megasite locations, as, conversely, the latter represent the making of a place and a territory ("mega-cluster") and its ancestral value for future generations (1000 years). Moreover, the ancestral power that ancient monuments provided for Early Medieval elites, is also not comparable to the megasites' mostly bottom-up negotiation of social space that lacks architectural monumentality.

Another non-urban settlement parallel can be found in Early Neolithic causewayed enclosures of Northwest Europe. Similar tighter social interactions, on a temporary basis, must have happened in these enclosed places, which developed at around the same time as the appearance of Trypillia megasites (late 5^{th} – 4^{th} millennium BC).

Although comparable social dynamics occurred during the collective construction and use of causewayed enclosures, their structures are remarkably different from the megasites' (Andersen 2010, 2015). While enclosures developed substantial enclosing features – such as palisades, ditches, and fences – only some Trypillia megasites only show ephemeral traces of a surrounding shallow ditch (Chapman and Gaydarska 2016), but present copious remains of residential architecture that is completely lacking in the Northwestern European sites (Andersen 2015, 803). Consequently, we can argue that both settlement forms represent places where various collective activities were performed by a portion of the population coming from a large hinterland, and that new form of identities start to develop even if based on non-permanent social interactions (Andersen 2010). However, the lack of residential features in the Northwestern European examples reflects a different level of supra-village social interaction occurring at the two settlement forms. Probably if we consider both as some sort of social experiment, we could argue that in the Trypillia case we are facing a different level of social aggregation that is moving towards a more regular and formal way of gathering. In both cases, though, the development of structured social hierarchies is not necessary to explain how these settlements came to be (Andersen 2010), even though the physical definition of an 'enclosed space' is arguably the result of a top-down decision to mark that specific portion of land or a negotiation between early settlers form different villages.

Overall, non-urban parallels are comparable to Trypillia megasites' modes of social interactions in terms of contacts between heterogeneous identities, but they cannot explain the dynamics of residential structure's development that is evident in the Ukrainian example here studied.

This aspect can probably be better explained by a reconsideration of the 'urban concept'.

All these terms and comparisons assess whether the case of Trypillia megasites fits diverse sets of criteria that define different urban settlement forms, such as low-density (Fletcher 2009) or clustered (R.J. McIntosh and McIntosh 2003), as well as non-urban ones. It seems that all the different sets of criteria, or measures, are trying to define the essential characteristics of what they want to define as 'city', thus giving the possibility of a specific site being considered as 'urban' within a set of variable meanings. With regard to the second conundrum raised by Gaydarska (2016), one step forward is the contextualization of a specific site into a framework of settlement history and habits, proposed by Gaydarska, by using, for instance, local names that describe how the site is perceived by the inhabitants. While this is possible in the case of written evidence or through ethnographical comparisons, it becomes quite problematic for prehistoric times - hence, the necessity, raised by Gaydarska, to advance a theoretical framework in support of the interpretation of archaeological material. In this sense, I propose to consider the concept of 'city' from an evolutionary point of view. Rather than trying to outline a universal network of measures or criteria that define a city, and then see whether the site under investigation can be considered as such, we might conceive the idea of 'city' as a concept in evolution. Therefore, processes, like the ones proposed by Flad (2016), rather than fixed conditions should be contemplated. If we break down the definitions proposed so far, and get to the 'primitive' features of an urban form as described in the etymological dictionary ***Origins***, this is defined as "an aggregation of citizens" (Partridge 1983, 101). As clearly elucidated by Emberling (2003), this highlights three basic elements of the city, 1) a community of people with forms of social and political organization which are different from pre-urban and non-urban communities; 2) the aggregation happens in a specific location, the city, which is a physical space and a conceptual map of urban residents and their neighbours; 3) the inhabitants – citizens – identify themselves with the physical space, thus creating an urban identity (Emberling 2003, 254). Thus the 'primitive' elements of an urban settlement can be defined as a community (larger than non- or pre-urban), in a specific (***author'snote***) larger space, with an urban identity, and (***author's note***) performing urban social activities. This definition, yet again a checklist, could be used as the 'primitive' definition of city. The evolution of this idea does not assume a linear trajectory, as many sites that fit this description did not 'evolve' into successful urban forms. And, conversely, not all the urban settlements started from this initial form. But in the overall evolution of the concept of city, we can argue that these are 'primitive' traits of the idea of a city.

The 'primitive' elements leave a degree of variability for what could be identified as agencies responsible for the emergence of cities; whether these were ***top-down*** coercive and hierarchical political authorities (Childe 1950), or ***bottom-up*** heterarchical processes (Crumley 1995). Moreover, the non-inclusivity of a ***permanent*** character in the 'primitive' form of a city, leaves out the need for a strong societal hierarchy to control high levels of scalar stress (Johnson 1982), the need for competing for food resources or land acquisition, the need for technological and infrastructural advances that allows the functioning of a large settlement, and, finally, leaves out the necessity of a hinterland that both support and depends on the urban settlement (Trigger 1972). From an evolutionary perspective, the ***permanent*** character in all definitions of city seems to be the trigger for the development of the social complexity necessary to coordinate a full-time large group of people closely interacting and sharing resources. Similar mechanisms happen in the 'transition' from mobile to sedentary communities.

The criteria here proposed as 'primitive' elements denote a strong component of people's identity. One of the earliest traits to develop was the idea of city as a special place, for the interaction of many people and for certain activities that were not normally performed in non-urban sites. Returning to the second of Gaydarska's list of issues, the way people and past actors perceived a site, would make it urban, "at that time", or not. Therefore, what could have been conceived as urban in the past might be seen as a "large village" today in the light of the evolution of the idea of city. Therefore, the temporal scale defines whether, "where" and "when" a site can be called urban or not.

So, were Trypillia megasites early cities or large villages?

The answer to this question depends on when they are defined. At the time of their development, Trypillia megasites, were probably perceived as 'urban', in the sense of special places, where a large part of the regional population aggregated, to perform communal and non-standard social activities for a limited period of time and coordinated by a self-organized supra-village organizational authority. In the AD 21st century, they are most likely seen as large villages where a large part of the population tried to coordinate communal activities without a strong social hierarchy (not materially visible). This worked for quite a long time, but then failed to develop into a new, long-term urban settlement form. Their 'failure' as first cities in Europe can only be acknowledged in the 21st century, but whether this was a sustainable settlement, social and political system that worked for a quite a long time and then dismissed, it will be hard to tell. Similarly, the proposed 'failure' of short-lived (approx. 150 years) massive sites like the Late La Tène ***oppidum*** of Bibracte (135 ha) as an urban centre (Moore et al. 2013, 510) can only be 'perceived' in light of the early development of the Gallo-Roman model. But this does not exclude the possibility that ***oppida*** like Bibracte were not 'perceived' as urban (in the proposed evolutionary way) from the people who lived and inhabited them. The long-lived existence of the French ***oppida*** (~ 300 years) makes them a sustainable and successful settlement model that can, as well as the Trypillia megasites, be considered urban at the time of their occupation and use.

Chapter 7: Conclusions

Chapter 7 concludes the thesis by pointing out and summarizing the original contributions of the research presented in the previous six Chapters and the extent to which these met the aims and objectives elucidated in the introductory Chapter 1. I shall then consider potential avenues for future research on the different aspects discussed in the thesis.

7.1 Thesis contents and results

Chapter 1 established the aims and objectives of the thesis, and how these developed independently from objectives 3, 4 and 6 of the underpinning project's aims. The main aims were to understand the Trypillia megasite phenomenon in its wider geographical and social context and to develop a theoretical and methodological framework for investigating urbanism from an archaeological point of view. These aims were then teased out into 5 objectives as follows:

1 – the assessment of the potential of satellite imagery and their analysis for the identification of Trypillia sites and megasites in the micro- and macro-surroundings of Nebelivka (the project's case study);

2 – the development of a field survey methodology that enables the discovery of Trypillia (as well as other periods) sites from surface scatters and a sampling technique that allows for the estimation of subsurface structures density;

3 – the definition of a research methodology (combining remote sensing and field survey) that enables the assessment of the legacy data and their potential for the contextualization of the megasite phenomenon within the broader Trypillia settlement patterns;

4 – the quantitative analysis of legacy and primary data in order to diachronically investigate the settlement dynamics of megasites and other Trypillia settlements.

5 – the development of an interpretative model that combines quantitative analysis and social theory in order to explain the formation, growth and demise of megasites and their interplay with the broader Trypillia group.

Chapter 3 framed the background to what is the theoretical approach adopted by the research, which tries to find a middle ground between the broad array of quantitative analytical tools that developed within archaeological research in recent years and the argumentation of social models that can explain the megasite phenomenon. The basic idea is that we can take advantage of the informative potential of 'Big datasets' and their capacity of providing us with trans-scalar (both spatial and temporal) patterns, but the results must be integrated within an interpretative narrative that is based on, but goes beyond, mere numbers and statistics. This meet part of the goal established in objective 5 with regards to the setting of a new theoretical framework for studying Trypillia megasites.

Chapter 4 analysed the full spectrum of available remote sensing datasets and assessed their potential for site recovery in the study area. The main result is that, despite the favourable conditions of land-use, high-level spatial and spectral resolution and a good understanding of taphonomic processes, remote sensing is not the best tool for a large-scale investigation of the Ukrainian forest-steppe archaeology and has developed limited potential for the detection of any kind of subsurface archaeology.

On the other hand, there is great potential in remote sensing for the detection and mapping of specific features such as burial mounds (***kurgans***) and traces of palaeo-channels. Moreover, for the sites that are visible on the imagery, remote sensing can help in the estimation of site sizes and consequently the assessment of legacy data.
Moreover, the introduction for the first time in the history of Ukrainian archaeology of systematic field survey represents one of the main methodological contributions of this thesis, as it led to the investigation of the immediate hinterland of a Trypillia megasite in a rigorous way. Furthermore, the application of a systematic sampling strategy allowed – in combination with remote sensing – an accurate assessment of the reliability of legacy data. This itself sets a new agenda for future fieldwork aimed at re-evaluating the site sizes of known Trypillia settlement, thus achieving a more complete and consistent set of data to be analysed as a whole. These results meet the goals formulated in objectives 1, 2 and 3 with regards to introducing new field methods, assessing the potential of remote sensing, and the combined use of these to evaluate the reliability of legacy data.

Chapter 5 addressed the gaps in history of Trypillia megasite investigations and proposed a nuanced way of studying their archaeological and historical relevance within an unprecedented scale of analysis. Namely, it proposed a new definition of megasites, which is not simply based on size and layout, but it also includes their spatial relationship with the broader settlement system. The main results of the spatial analyses can be summarized as follows:

- Megasites are clustered in a specific territory (the Southern Bug-Dnieper interfluve), when compared to the overall distribution of Trypillia settlements.
- The reasons why megasites are clustered in the Southern Bug-Dnieper interfluve are to be sought in the social rather than the environmental domain.
- The hinterland of megasites, which is conceived as their social catchment is estimated to be as broad as 100 km.
- The immediate surroundings of megasites are archaeologically 'empty'.
- Megasites can comfortably accommodate all of the coeval settlements at any one time.

The main outcome of these results is that megasites can be defined as a specific settlement form within the context of a coeval settlement system, and that this relationship remained constant for most of their existence (approx. 1000 years). These results meet the goal established in objective 4 of developing a set of analytical tools to investigate the settlement dynamics that contextualised the appearance, growth and demise of megasites.

Chapter 6, finally, drew together the results of the spatial analyses and some of the results of the overall project, in order to offer a synthetic interpretative model of the Trypillia megasite phenomenon. The proposed narrative teased out a number of themes that represent a major contribution to Trypillia as well as urban studies. The main results can be reviewed as follows:

- Trypillia megasites were seasonal gathering places that drew together a large part of the population from considerable distances of up to 100 km.
- The population developed a 'megasite identity' through the interaction of different 'village identities', leading to the formation of temporary supra-village regional heterarchical social coordination.
- The apparent 'empty' space that characterises the majority of megasites is actually the 'materialization' of the 'megasite identity'.
- The urban label can be assigned to Trypillia megasites only within a local coeval temporal framework. However, in a long-term temporal scale of the last six millennia, they are to be conceived as large/overgrown 'villages'.

These results meet the goal of proposing a nuanced model for the interpretation of megasites based on the combined use of quantitative analyses and social theory, set by objective 6.

7.2 Original contribution to knowledge

7.2.1 Contribution to Trypillia studies

The major original contributions of this thesis to Trypillia studies are both methodological and theoretical. These contributions represent methods, ideas and concepts that have never been considered before within the history of investigations. Methodological:

- The introduction for the first time of systematic field survey in Ukraine.
- The assessment of the full potential of remote sensing for the detection and mapping of Trypillia sites.
- The assessment of the accuracy, and quantitative analysis, of the whole set of legacy data of known Trypillia sites.

Theoretical:

- A redefinition of megasites as spatially related with the broader context of coeval settlement systems.
- The introduction of the idea of 'seasonality' within the debate on megasites.
- The discussion of the social meaning of the 'empty spaces' that are characteristic of the traditional definition of megasites.
- A social interpretation of the internal development of megasites, thus challenging the assumption that all the dwellings were coevally occupied, along with the introduction of the concept of 'heterarchy'.
- The introduction of a multi-temporal perspective to define the urban nature of Trypillia megasites.

7.2.2 Contribution to urban studies

Some of the themes proposed and discussed in the thesis can be also considered original contributions to the archaeological study of urbanism.

- The proposed long-range social catchments of megasites contribute to the discussion of what can be defined as urban 'hinterland'. Traditionally considered as an economically depended territory in the immediate surroundings of the city (or central place), this might have been a much wider catchment of people in the early stages of urban development, whose social interactions were less structured and more occasional.

- The provisional nature of these interactions could have been materialized in large, seasonal gathering places, which were perceived as 'special places' for the performance of 'special collective activities' comparable to our idea of urban functions. The suggestion is not to exclude a seasonal component in the definition of early urban settlements.
- More generally, the idea of conceiving the 'city' as an evolving concept that could have been far less structured and permanent in its early stages of development, which may have led to possible failures. A more dynamic and multi-temporal perspective on the study of urbanism that could contribute to the understanding the diversified trajectories of this global phenomenon.

7.3 Future research avenues

The state of the art in Trypillia studies is still at the beginning when compared with the methodological and theoretical achievements of Western archaeologies. However, the so-called 'Second phase of methodological revolution' in Trypillia archaeology brought new levels of detail at the intra-site level with modern fine-grained geophysical plans (Chapman et al. 2014b; 2014c; Rassman et al. 2014: 2016). Therefore, the knowledge at the site level is now increased considerably and more targeted test-excavations can be carried out on a number of different archaeological features. In parallel, this thesis brings the wider settlement dynamics into the debate on Trypillia megasites, with all the contributions described above. However, the research is still at its beginning and the recent research projects set a new agenda for the next, at least, 50 years of Trypillia archaeology both in terms of field methods, excavation and analysis and in terms of historical narratives.

Traditional field methods have been enriched by modern geophysical surveys that are producing amazing results, but mostly on megasites; it would be therefore necessary to survey smaller settlements, in order to gain the same level of detail, thus allowing a more targeted excavation agenda looking at the neighbourhood and household domains in smaller Trypillia villages. This would strengthen our theories and interpretation on their interactions with megasites.
Moreover, the introduction of systematic fieldwalking and surface collection provided Trypillia archaeology with a new tool to investigate the immediate surroundings of megasites and smaller sites and assess if there is any substantial difference in the impact that these two settlement forms have on the local environment. Additionally,

the analysis of more pollen sequences collected in the proximity of smaller sites would further investigate the human impact of villages in the landscape.
Extensive fieldwalking, at a regional scale, would improve the knowledge of Trypillia settlement patterns in a more even and consistent manner, along with the field assessment of every site reported in the Encyclopaedia.
At the site level, new ways of investigating the 'empty spaces' would help in the understanding of their meaning. "Dirt DNA' analysis, phosphate, micro-morphology and maybe shovel tests might shed some light on the functions of these spaces.

In a broader perspective of research questions, the formation and demise of Trypillia megasites still remain dubious. Therefore, new research agendas looking at Trypillia interactions with steppe communities, for instance, could bring new ideas and evidence on the role of megasites and how they have been abandoned 200/300 years before the end of the making of Trypillia pottery. The 'two ends' need to be investigated as independent phenomena since the abandonment of megasites seems to be much earlier than the end of Trypillia culture. At the other end (or better start!), also the drivers that prompted the development of megasites need to be sought within the group as well as in its external contacts.

Overall, much more still need to be done in Trypillia archaeology, and the attention should be focussed on smaller sites as well as to larger scales of analysis. The problem would be finding a convincing way of writing a grant proposal for a project on early urbanism that wants to look at empty spaces and small villages!

Appendix A: Software and routines

This appendix explains the routines performed and the software used for the data analysis. For the data see Appendices B and C.

SOFTWARE	ROUTINES
Erdas Image 2014	- Georeferencing CORONA imagery using the 5th polynomial transformation. - Image enhancements of WorldView-2 multispectral imagery like (PCA, Decorrelation Stretch, Equalization).
ESRI ArcInfo 10.3	- Mapping archaeological features from satellite imagery and storing the information in a bespoke File Geodatabase. - Plotting and storing in File Geodatabase format small finds collected during field survey and site sampling. - Plotting and storing in a bespoke File Geodatabase legacy data derived from the Encyclopaedia. - Global and Anselin Local Moran's I test performed to analyse clustering and outliers in the settlement data.
R statistical package (St. Andrews CRAN repository)	- Logistic regression test using the *logit* type of the *glm* function for binomial values. - Kernel Density Estimation of site size using the generic *density* function. - GINI coefficient using *gini* index type of the *ineq* library.

Appendix B: Field survey data

The content of this appendix can be found in the folder: ***Appendix B*** contained in the flash drive attached to the volume. All the data utilised in this thesis are projected to UTM WGS84 36N. The contents of the folder are the following:

FILENAME	**CONTENTS**
Field_survey_small_finds_5km.shp **(ESRI shapefile format)**	The file contains the GPS points result of the nonsite sampling strategy adopted during the first field survey season in Nebelivka micro-region (5 km radius).
Macro_region_sites_25km_summary.xlsx **(Excel spreadsheet)** **Macro_region_surveyed_sites_25km.shp** **(ESRI shapefile format)**	The files contain a summary of the sites recovered and sampled in the macro-region (25 km radius), with the estimated extend. Two formats with the same content are provided
Site_sampling_25km.shp **(ESRI shapefile format)**	The file contains the GPS points result of the site sampling strategy adopted during the peri-fluvial field survey to estimate site sizes in Nebelivka macro-region (25 km radius).
Site_sampling_25km_database.xlsx **(Excel spreadsheet)**	The file contains the result of material counts of the site sampling, reporting quantities and types of pottery and special finds collected.

Appendix C: Database and spatial statistics

The content of this appendix C can be found in the folder ***Appendix C*** contained in flash drive attached to the volume. The folder contains the Trypillia database and the results of the Anselin Local Moran's I test performed on the settlement data.

FILENAME	**CONTENTS**
Trypillia_database.xlsx **(Excel spreadsheet)** **Trypillia_database_GIS.shp** **(ESRI shapefile format)**	The file contains the database generated after the data cleaning and plotting of the records from the Encyclopaedia. It represents the core of the quantitative analyses. See Table 4.2 for a description of the fields in the database. A GIS format of the database is included.
Ans_Loc_Morans.xlsx **(Excel spreadsheet)**	The file contains the results of the Anselin local Moran's I test. The descriptions of the different fields are reported in the table. Descriptions of the table fields can be found in the spreadsheet.

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